



2002 is a significant year for conservation in Seychelles as we mark the 10th year of national NGO conservation work and the 10th issue of *Phelsuma*. Over the 10 years that we have been producing this journal constant alterations have been made. We have now settled into a stable format and fulfilled our aim of ensuring wide dissemination of reliable information around the region. The 10th issue includes papers and notes from all island groups covered by the journal: Seychelles, the Comores, the Mascarenes and Madagascar. Plants and animals are covered and, of the animals, there is a wide spectrum from taxonomic papers on spiders to ecology and conservation of birds.

Over our first 10 years *Phelsuma* has seen the publication of a wide range of papers and notes - from geological reconstruction and general ecological papers to accounts of genetic variation, species records to molecular phylogeny. Particularly valuable contributions have been the publication of new records for the islands and rediscoveries of 'extinct' species. This issue sees the 19th species description in *Phelsuma*, a significant achievement for a small journal. To do this we have been supported by a total of 67 authors, representing a wide range of backgrounds, countries and interests. Significantly, nearly a third are amateur biologists whose contribution to the continued development of biological knowledge of the region is immense but is usually overlooked. One of the most important roles *Phelsuma* plays is to encourage both amateurs and professionals to publish their information. Biological understanding and conservation practice can only make progress if the information, whether it be research findings or casual observations, is published and distributed to a wide audience in the region. Unpublished data will always remain worthless and as editor of *Phelsuma* I continually seek to encourage these with observations to make them available. At present this is hindered by two factors. One is the lack of confidence of many amateur observers; the proactive editorial policy of *Phelsuma* ensures that peer review can be used to encourage amateurs to publish. The second factor is an unfortunate trend towards 'confidentiality' in conservation (and related research projects) in the western Indian Ocean. This prevents access to much potentially useful information and devalues the projects concerned. NPIS has an open policy to information and accurate publication of progress and results is an integral component of all our projects. I would like to take this opportunity to encourage all researchers and conservationists to publish - confidentiality only breeds the impression that there is something to hide.

The progress of *Phelsuma* since 1992 has been remarkable considering our minuscule budget and almost complete lack of facilities. We look forward to continuing this development through the next 10 years with the continued support of our authors and subscribers.

J. Gerlach
Editor

CHAIRMAN'S REPORT

Ten years ago, on 3rd June 1992, the Nature Protection Trust of Seychelles became the first ever Seychelles conservation NGO. For a purely voluntary organisation, with a small but dedicated membership, there have not all been easy years. Prior to 1992, conservation and environmental matters were in the hands of government with the exception of the foreign owned bird reserves of Anse and Cousin. The sudden arrival of an NGO seeking involvement in conservation matters, while fulfilling the democratic aspirations of a multi-party system, was nevertheless viewed with distrust and suspicion. Our own inexperience in dealing with the attitude of government staff, who were accustomed to being the only people with a voice in conservation affairs, and disappointment at being denied recognition for our efforts led to some acrimonious debates within our membership and with government. But over the years we have developed a good co-operative working relationship.

Our membership of IUCN - the World Conservation Union - which we joined in 1996, has kept us in touch with organisations around the world, and although we do not share many of the problems of the East Africa region to which Seychelles belongs - our contacts with other members have strengthened our resolve to continue working for wildlife and the habitats which are vital to its survival.

Ten years of our publications, Birdwatch and Phelsuma, have brought a large amount of information into the public arena. One of the rewards of working in conservation is the praise and encouragement that comes directly from the public. Their support is often unsolicited and given in the knowledge that dedicated conservationists are their proxy for doing what they would wish to do, but cannot. It is good to know that ten years of regular articles about natural history in the media have brought pleasure and interest to the general public. It is to them that we dedicate our projects, and their generosity is our lifeline.

While most financial support this last year has come as small donations from visitors to our information centre on Silhouette, the following individuals and organisations have helped in other ways.

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Mr. William Patrick Watson
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Rolf C. Hagen Inc.
British Chelonia Group
Dr. Joachim Steinbacher
Third World Academy of Science
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Promises and logistic supports
Donation for Silhouette Project
Communications equipment
Temptin food
Radio tracking equipment
Donation for "Birdwatch"
Research Equipment
Donation for publicity material
For acting as our Hon. Auditors

Volunteers

Nadine Clark
Mark Openshaw
Ann & Bill Truscott

Aurèle Laminé
Zoe Cokerless
Anita Linsell

Our grateful thanks to all and especially to our volunteers who paid their own fares and accommodation – all for the pleasure of tracking-out the tortoises; among other duties. We also wish to thank the group of London Venture Scouts and their Seychellois colleagues, for helping to remove invasive plants at Jardin Maillon.

Visiting Scientists

Other visitors of note this last year included Dr. Richard Huxford from the University of Liverpool, who came to Silhouette for a week in June 2001 to find and identify freshwater crabs in high-altitude streams.

In July 2001, Prof. Michael Samways from the University of Natal, who is Chairman of the IUCN Southern African Invertebrate Specialist Group, spent a week on Silhouette looking at dragonflies and damselflies. His visit coincided with that of Bill and Chris Wain who are dragonfly enthusiasts from the U.K. Their confirmation of the existence on Silhouette of the Seychelles fineline damselfly (*Trithemis affinis*) was so exciting that it somehow slipped into last year's Flukoma (Vol. 9).

Julian Pender Hume spent 3 days on the island looking for possible fossil deposit sites. His only reward came with the uncovering of some fragments of tortoise carapace at the entrance to one of our two sheath-tailed bat roosts.

Drs. Mick Frogley and Dominic Kalsvorn from Sussex University brought a group of 12 students to Seychelles on a field course in March 2002. Their work on Silhouette enabled them to set up field projects based on our research and monitoring programmes. The success of the trip will, we hope, encourage them to return in the future.

Dr. Michael Madl from the Vienna Naturhistorisches Museum came to Silhouette for a week in May, to study wasps, together with NPIS Council members Pat Mayot and Mo van der Merwe.

Oversseas meetings and visits

Last July we went to Mauritius and had the pleasure of meeting Dr. Carl Jones from the Mauritius Wildlife Foundation. He kindly put Darryl Birch, who had been a volunteer for our projects on Silhouette, at our disposal for a day. This gave us a wonderful inside view of their bird projects and the forest regeneration project in the Black River Gorges.

In November last year, our Scientific Coordinator, Dr. Justin Gerlach was invited to take part at an IUCN Species Survival Commission 'Invertebrate Scoping Workshop' in Washington D.C. This was attended by 12 invertebrate conservationists, representing 7 countries, 7 specialist groups and SSC headquarters and Red List and Trade programmes of IUCN. The meeting's aim was "enhancing IUCN's input to global invertebrate conservation through the invertebrate network of IUCN's Species Survival Commission." (IUCN/SSC/CHSG 2001).

In January 2002, Justin Gerlach attended the International Turtle & Tortoise Symposium in Vienna. The meeting was attended by experts from around the world and presentations were

given on every genus, and nearly every species, of tortoise and fresh-water turtle. The enormous significance of the region as a hotspot of tortoise endemism was recognised in the dedication of a whole section of the meeting to Madagascar and Seychelles (co-chaired by Justin and Dr. Gerald Kuchling).

In February we were in England to visit the Eden Project where, in collaboration with the Seychelles Botanical Gardens, research is being carried out on *Sapotium gordonii* – a plant which is clinging on to existence on Mahe but is quite well-established on Silhouette. Alison Griffiths kindly showed us around and took us to the nurseries where the Seychelles plants were growing. On a purely personal level, I found the “no expense spared” appearance of the project quite overwhelming, knowing how in-situ conservation has to survive on bent nails and second-hand planks! Still, if this is a way to fund research, it is good and it was an excellent and informative visit.

The Seychelles Giant Tortoise Conservation Project

After another disappointing breeding season in 2001, with numerous infertile eggs being laid, a decision was taken to allow the two groups of six to mix. It is hoped that having a herd of 12 animals will heighten competition between the males and thereby increase fertility.

This year we have constructed a walled enclosure adjacent to the Information Centre for use as a natural incubator. The problem with leaving tortoise nests in the main enclosures is the difficulty in protecting them and the impossibility of finding hatchlings if they emerge and disperse at a time when no-one is around. There is still much to be learned from the artificial incubation of the eggs but most eggs will now be returned in the secure hatchery and allowed to develop in natural conditions.

Seychelles Terrapin Conservation Project

We have had another successful year with the *Pelusio subreiger* terrapins. They produced a further 12 hatchlings this year, bringing the total up to 22 since the start of the project.

In March an experimental release of 5 adults (3 females and 2 males) into the marsh at Grande Barbe was started. These terrapins are fitted with radio transmitters which will enable us to monitor their dispersal and territory size. The data gathered is essential for planning future re-introductions.

Some progress has been achieved with the *P. castaneoides* terrapins but full success has eluded us again this season. The regime started last year of introducing one female to a pond containing two males, leaving her for a month and then removing her, has resulted in eggs being laid. The eggs were, however, laid in the ponds and were damaged before discovery. The females will be isolated in shallower ponds this coming season, thus making it easier to see the eggs and rescue them. An action plan to ensure the future of both species in Seychelles has been drafted and circulated to various groups, with an interest in terrapins, for comment.

Indian Ocean Biodiversity Assessment 2000-2005

This project has continued with the majority of the granitic islands visited. It is expected that

the surveying the granite islands will be completed in 2002. Early results indicate a wide range of new records and "extinct" species located.

Silhouette Conservation Project

This joint project between the NPTS and the Islands Development Company (IDC) is the main focus of our activities on Silhouette. Biodiversity surveys have continued throughout the year and have yielded many interesting finds. These include a number of unrecorded spiders and a cockroach that measures less than 2 mm.

During the north-west monsoon we were able to plant out more seedlings in the lowland forest regeneration project. *Antimimetus* *anisee* seedlings planted earlier last year survived the extremely long dry spell and are now beginning to show signs of growth. The seedlings planted at Jardin Marron have fared better than those at lower altitude, possibly due to higher rainfall.

Research into the ecology of the marsh at Grande Barbe continued this year with the assistance of Sussex University students. This follows on from the project carried out there last year by Dave Simpson and Audrey Royo. Of particular interest will be the observations made by two mature students on the ecology and behaviour of various odonata (dragonflies). When added to the observations of Prof. Michael Samways and Chris and Bill Wain, this data will contribute to our understanding of the ecological needs of the dragonflies.

The development of an eco-friendly new lodge on North Island is proceeding as planned and it is expected that the first guests will arrive at the end of this year. Their island restoration project is underway and our cooperation has been sought and given, with the agreement to collect seeds from Silhouette for cultivation in their nursery.

This new lodge, only 5 kms from Silhouette will increase the level of nature tourism on our island. There is at present a demand from the Silhouette Island Lodge guests and other day visitors for guided walks. Since April we have also had weekly calls from a small cruise ship, "The Pearl of Seychelles". These visitors make a two-hour shore excursion which includes a visit to our Information Centre and projects.

The next ten years should be an exciting time for the Nature Protection Trust of Seychelles and for Silhouette. We look forward to your continued support and encouragement and hope that together we can work to conserve the wildlife and the habitats upon which we are all so dependent.

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R. Gerlach
Chairman

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Habitat use by a population of the Seychelles kestrel (*Falco araea*)

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Abstract: The Seychelles kestrel *Falco araea* is classified as a Vulnerable species with nine breeding populations restricted to two islands of the Seychelles group (Mahé and Silhouette). An attempted reintroduction to Praslin in 1977 has failed to date. It is the world's smallest kestrel species and is adapted to preying on small insects in forest habitats. The habitat preferences, territory size and distribution on Silhouette island was studied confirming previous reports of a preference for lowland habitats. The Silhouette population is estimated at 48 pairs, showing no significant change from the previous (1981) estimate. Exceptionally small territories (as small as 9.0ha) were found in habitat mosaics of lowland forest on bare rock, associated with abundant cliff nesting sites and high forest population densities. The larger island of Praslin supports very few kestrels and as the size distribution of forests on that island is skewed towards large individuals, this may result in food scarcity. Combined with nest site scarcity the paucity of small prey may cause the lack of significant population recovery on Praslin.

Key words: conservation, *Phaethon*, population, Praslin, Silhouette

Introduction

The Seychelles kestrel *Falco araea* Oberholser, 1917 is endemic to the granitic Seychelles islands. It is the world's smallest kestrel (Cade 1982), a characteristic that may be an adaptation to small isolated islands. The species has a short wingspan comparable to that of the New Zealand Falcon (*Falco novaezealandiae*) (Cade 1982), although not as short as the Mauritius kestrel (*Falco punctatus*) (Jones 1987; Greenbridge 2000) and is adapted to hunting in forest habitats. Other more subtle adaptations may also exist but have not been detected to date.

Historically the Seychelles kestrel was recorded as a resident species from the islands of Mahé, St. Anne, Cerf, Long, Thérèse, Silhouette, North, Praslin, Carriou, La Digue, Felicite and Marianne (Newson 1867, Oustalet 1878, Harcourt 1877; Vesey-Fitzgerald 1940) (Fig. 1). Following human colonisation of the islands in 1772 it was heavily persecuted directly and was brought close to extinction in the mid-1900s; an estimate in 1969 put the population at fewer than 30 birds (Gaymer *et al.* 1969). Further population reductions were suggested to be caused by barn owl nest site competition (Fisher *et al.* 1969) resulting in the extinction of the population on La Digue Island (Penny 1968). In 1974 breeding was believed to be restricted to Mahé and Silhouette islands and an estimated 100 pairs were present on Mahé (and an unknown number on Silhouette). Protection under the Wild Animals and Bird Protection Act has allowed the population to recover and in 1975-7, 370 pairs were estimated to be present on Mahé (Watson 1981) and single pairs reported on St. Anne and Cerf (Pearce *et al.* 1974; Temple 1977). The Silhouette population was only evaluated during a short visit and an estimate of 36 pairs made (Watson 1981). On Praslin the kestrel was reported to be extinct by the mid 1970s although 1-2 had been observed in 1970-3 (Pearce *et*

et al. 1974) and reports of kestrels on Praslin and La Digue in 1975-7 were suggested to be juveniles moving from Mahé (Watson 1981, 1989) although these did not form a viable population. Approximately 10 territories were present in 1980-7 (Watson 1981, 1989; Skerrett *et al.* 2001), possibly rising to 20 pairs (reported from unknown sources - Collar *et al.* 1994) and subsequent declines suspected (Rocamora 1997). In recent years small numbers have been seen on Cerf, La Digue and North Islands, although it is not known if any of these represent permanent breeding populations. It is currently categorised as Vulnerable by IUCN (Hilton-Taylor 2000).

Research into this species has provided population estimates of varying reliability, and basic data on reproduction and diet (Pearce *et al.* 1974; Watson 1981). There have been few in depth studies of raptors on small islands and the diminutive Seychelles Kestrel makes a good model of small island adaptations. The Silhouette population is isolated from the main population on Mahé by 19km, a distance that is likely to prevent inter-island dispersal in a short-winged kestrel (C. Jones & D. Birch pers. comm.). The island retains most of its original forest cover and provides a relatively small (1992ha) discrete area to study the natural ecology of the Seychelles Kestrel in the absence of modern anthropogenic disturbances.

The only studies of the kestrel on Silhouette island comprised of 4 short visits in which Watson (1981) provided a population estimate of 36 pairs based on only two imprecisely defined areas totalling 630ha. Greg-Smith (1979) published notes on its distribution and in 1996 brief visits to Silhouette by two expeditions estimated the population to be "less than 20 pairs" (Rocamora *et al.* 1996) or "at least 15 pairs, and certainly no more than 20 pairs" (McIlhenny *et al.* 1996). Recent observation suggest that these population estimates are inaccurate with local population densities being higher than published estimates. Local reproductive success appears to be high with observations being made of nests rearing 2 chicks. The territories are also exceptionally small (some being smaller than 20 hectares, in contrast to published home range estimates on Mahé of 49.8-103.2ha).



Fig. 1. The range of the Seychelles Kestrel, islands with recorded historical populations.

Methods

The present study compiled data on kestrel distribution and location of territories on Silhouette island in 1990-2001 covering almost all the island (530 hectares intensively) and in all habitat types. The locations of visible or audible kestrels were recorded and where possible the birds were watched in order to identify nest sites and territory boundaries. In low land areas with good vantage points this could be determined with accuracy, at higher altitudes fewer vantage points were available and few territory boundaries could be determined accurately. The data were combined with habitat maps (Gerlach 1993) to produce habitat structured population density estimates.

The distribution and abundance of the main prey species was studied using the 'Phelsuma index' (Watson 1991) where 100 trees are studied in each area (coconut crowns below 200m as l and *Prosesternaria foliata* or of 15-35cm diameter at higher altitudes) by scanning the tree one with binoculars from a distance of 30m and recording the number of day geckos (*Phelsuma* spp.) seen. This provides comparative abundance measures rather than absolute measures and was used to provide a direct comparison with the earlier study. Absolute abundance measures were obtained by observing 20 trees for 30 minutes each, recording all the individual geckos observed. This was combined with existing data on tree density and diversity (Gerlach *et al.*, 1997; Gerlach in prep.) Skink numbers were determined using transects along forest paths. Every 100m along a path the number of *Mabuya zeyheri* skinks which visible on either side of the path was recorded. The altitudes of each of these 100m sections were determined from a contour map to give an indication of the relationship between skink abundance and altitude.

Kestrels successfully capturing a gecko on the trunk or branch of a tree was observed on 20 occasions. In each case the approximate position of the gecko on the tree was noted as a proportion of the total tree height.

Regurgitated pellets were collected from accessible roosts on Mahé and Silhouette and dissected to investigate diet. Existing accounts describe the diet of the Mahé population but do not quantify prey size. Accordingly selected bones were measured and compared to skeletal material in the Nature Protection Trust of Seychelles (NPTS) collection on Silhouette to determine which size categories of prey are eaten. This was compared to data on size distribution in the gecko (Gardner 1944, Radtkey 1996) and skink (Gerlach in prep.) populations.

Results

16 territorial pairs were located on Silhouette (Fig. 2) in all habitats except mist forest and *Dioscoreopteris linearis* scrub (Table 1; Fig. 1). The areas of the territories varied in different habitats (Table 1).

Kestrel territory size was found to be positively correlated with altitude and negatively correlated with the abundance of both reptile prey species (Fig. 3). The values of the *Phelsuma* index were found to be higher on Silhouette than Watson's (1991) data from Mahé (43-210 and 10-60 compared to 44-83 and 20-49 at <200m and >300m respectively).

All successful captures of geckos on trees were in the upper 70% of the tree. Within this 70% all 20 captures were evenly distributed.



Fig. 2. Location of identified territories on Silhouette island, dark shading shows areas of territory overlap

Table 1. territories located in terrestrial habitats on Silhouette. Habitat types modified from Gerlach *et al.*, 1993 and Gerlach, 1998

Type (area)	Area studied (ha)	Territories	Territory size (ha) range, mean	% overlap	Pairs
Coastal plain/scrub (195.8)	50	3	11.4-12.05-12.3	10	6
Coastal forest & glacia (157.9)	60	8	9.0-12.3-18.1	15	21
Mac-stem forest & glacia (349.2)	180	3	28.3-22.8-25.0	0	7
Palms rich forest (1087.3)	160	2	45.0-167.5-80.0	0	14
Mont forest (216.5)	30	0	-	-	0
<i>Acrocygus</i> scrub (70.3)	30	0	-	-	0
Total					48

Pellet analysis found a predominance of lizard prey as reported previously (Feare *et al.* 1974, Watson 1981), with both *Phelsuma* spp. and *Mabuya seychellensis* represented. Prey sizes were in the range 19.3–64.6mm snout-vent length (Table 2). These are compared to population size ranges in Fig. 4.

Discussion

The population densities recorded in the present study cover a wide range, including much higher values than previously recorded for the Seychelles kestrel. Feare *et al.* (1974) estimated home ranges to be 49.8–103.2ha (mean = 82.3, n=5) while Watson (1981) estimated population density to be 1 pair per 45ha on Silhouette and 38.8ha on Mahé. The present estimate of territory sizes of 9.0–90.0 (mean = 18.3, n=16) is considerably smaller than previous estimates. Due to considerable territory overlap at low altitudes the population density is 1 pair per 7.8–80/ha depending on habitat. The previous population estimate for Silhouette was given as 36 pairs (Watson 1981) but was based on an incorrect measurement of island area. Once corrected it gives an estimate of 45 pairs. The new estimate allowing for habitat variation is 48 pairs (Table 1). Although these estimates are not directly comparable their similarity suggests that the population has remained stable over the last 25 years.

Table 2. Prey composition and sizes. Lizard snout-vent lengths (SVL) are given as range with mean in parentheses

Island	N	Insects	Lizards	Snails	Other	SVL
		Cockroaches	Scorpions	Geckos		
Mahé	6	20%	10%	10%	30%	20%
Silhouette	10	35%	50%			25%

Size of item	frontal	distal	maxilla	tip	lower jaw	base	total	SVL
Males 2 - Mahé	1.0	-	-	-	-	-	-	18.7
Phelsuma - Mahé	-	-	5.0	9.0	-	-	9.0	48.3-50.1 (50.0)
Phelsuma - Silhouette	-	6.5	2.0	-	5.0-6	5.3-7.8	8.3-10.0	19.3-64.6 (34.6)

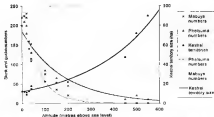


Fig. 3. Relationship between kestrel territory size, prey abundance and altitude

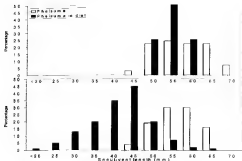


Fig. 4. Size distribution of kestrel prey - a. Mahé b. Silhouette

The highest population densities and the smallest territories are found in coastal habitats, mid-altitude and palm rich forests. This finding is broadly in agreement with a previous report of a negative correlation between kestrel sightings and altitude (Greig-Smith 1979). Similarly, Feare *et al.* (1974) found the smallest home ranges in coastal plantations and the largest in high altitude primary forest. The high population densities recorded on Silhouette can be related to availability of food and abundant nesting sites (dead trees and rock crevices). Measures of food availability (skinks and geckos) show exceptionally high availability on Silhouette (*Pelvicornis* index, 1.84 times higher than Watson's 1981 Mahé data). All the diurnal geckos and skinks on Silhouette fall into the size range of items recorded in pellet analysis (Fig. 4). Additional items recorded are insects (including cockroaches and scarab beetles in the present study), rats (only mice were found), birds, lizards and chameleons (Watson 1981). Bird records appear to be rare opportunistic catches of Madagascar fody *Foudia madagascariensis* (Watson 1981), Seychelles nuthatch *Nectarinia sechellensis* (R. Giffach 2001) and Seychelles white-eye *Zosterornis modesta* (G. Rocamora pers. comm.).

The size difference between territories on Mahé and Silhouette may be associated with nesting success as well as food availability. It has been reported that lowland (<200m) territories on Mahé use coconut trees as the main nest sites (46% of pairs) with just over half as many using cliffs (28%) despite cliff nesting pairs having high success rates (76% fledging chicks compared to 19%) (Watson 1991, 1992). At higher altitudes 69% used cliffs (Watson 1992). Such preferred nest sites are largely restricted to the higher parts of Mahé whilst the more rugged topography of Silhouette results in an abundance of cliff-nesting sites at all altitudes. Correspondingly all nest sites located on Silhouette are on cliffs or in tree cavities (which also have a high fledging success rate – 65%; Watson 1991).

These findings indicate that the Seychelles kestrel is well adapted to the mosaic of rock and forest habitats of the granitic Seychelles islands. It has the potential for a high reproductive output (clutch size of 2-3, mean = 2.63, Watson 1991) and long life-span allowing flexible population dynamics as is found in many other insular species (Gierlach 2001). These characteristics have facilitated recovery from population declines in the mid 1900s on Mahé and (it is assumed) Silhouette. The magnitude of the declines and recovery can only be guessed at in the absence of early population assessments. A similar recovery did not occur on Praslin, which seems to have retained a population of just a few pairs since the 1970s. There has been no attempt to determine a reason for the lack of recovery despite abundant gecko prey. It is possible that nest sites on Praslin may be limited. The island does not have the extensive cliffs that are found on Mahé and Silhouette and forest cover is limited to 10% (compared to 80 and 95% for Mahé and Silhouette respectively) will provide fewer tree cavities. Kestrels on Praslin may be forced to nest in sub-optimal sites such as palms and buildings, reducing fledging success and population growth rates. However, the birds colonising La Digue might be expected to be more successful due to the cliffs and more extensive forest cover (90%) of that island. The failure of colonisation, despite at least one breeding attempt in 1992 (B. Bockett pers. comm.) indicates that other factors may be involved.

Mahé and Silhouette kestrels feed selectively on small skinks and geckos (20-60mm snout-vent length range: Friedman 2-way ANOVA by ranks $F = 7.9285$, $P < 0.05$). On Praslin and La Digue *Phelsuma* gecko size range is significantly larger (means 63 and 62mm respectively, compared to 54mm - Mahé, 52mm - Silhouette; Gardiner 1984, Radkey 1996). Furthermore a size-related dominance hierarchy among *Phelsuma* results in larger individuals forcing smaller ones into low growing vegetation (Gardiner 1984). Only 40% of *Phelsuma* on Praslin are in the kestrel prey size range and 20% of these are found in the band of vegetation used by kestrels in hunting. This abundance of suitable prey is 10.5-18.4 per hectare in coastal and lowland habitat, 31.2 in mid-altitude forest and only 7.3 per hectare in open eroded areas (after Evans & Evans 1980, Gardiner 1984). This range of 7.3-31.2 is comparable to sites over 350m above sea level on Silhouette where kestrel territories are large (20-90 hectares). This suggests that kestrels will have the smallest territories and be most abundant in mid-altitude forest (20 hectare territories) and lowland habitat (25 hectares), but scarce or absent from eroded land (predicted territory of over 250 hectares). This is in accordance with the known distribution of kestrels on Praslin which are almost entirely restricted to the southern, forested quarter of the island (Watson 1981; Roosemore 1997). 10 pellets of a kestrel on Praslin were examined and found to contain insects only, a diet which may not be suitable for successful reproduction and may be the result of the suggested food scarcity.

Seychelles kestrels are well adapted to the conditions of the granitic islands with adaptive reproductive output and a predation strategy suited to the available prey. The selection for a short wingspan to facilitate dynamic flight in forest habitats contributes to its success as a lizard predator but does reduce the potential for inter-island dispersal. This in turn may prevent the Seychelles kestrel from recolonising islands after local extinctions. The successful recovery of the Mahé and Silhouette populations contrasts with the remaining vulnerability of the Praslin population which highlights the ecological differences between these islands.

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Roseate terns on Arde Island: the contribution of 19 years of monitoring to the conservation of an endangered species

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Abstract: The roseate tern *Sterna dougalii* on Arde Island has been studied extensively and intensively since 1984. This paper synthesises 19 years of data on roseate tern breeding numbers and productivity in order to identify possible limiting factors and assist the conservation of the Arde population. Between 1984 and 1985 the breeding population was estimated from counts of incubating birds from suitable viewpoints. Since 1996 all nests have been counted 11 days after the laying of the first egg. Until 1996 chick survival and productivity (α') of chicks fledged per breeding pair) were estimated from regular visits to viewpoints. Since 1997 reproductive parameters have been studied in detail in study quadrats. Studies of nest-site selection, foraging behaviour, diet, chick-feeding rates and impact of human breeding success and adult survival were conducted between 1997 and 1999. Overall, the breeding population crashed from 4 300–4 800 in the 1970s to about 1000 pairs in 1985. Since 1985 the breeding population has shown wide annual fluctuations. In spatial terms there was a tendency for concentration in only one major colony. In the 1980s, about 50% of the roseate terns nested in an open area, the Lodge Glade, but this colony was abandoned in early 1980s, apparently due to growth of *Thuus* spp. which has densely competed for nests, entangling both adults and chicks. The spatial distribution of colonies suggests that roseate terns may avoid areas with Sooty Terns. Within colony-rates roseate terns select concealed nest-sites. These appear to protect chicks from attacks of adults and kleptoparasitism. Gulls (*Mullus*) comprised the large majority of the food delivered to chicks. The breeding success was determined by food shortage, tick infestation and site specific aggression of chicks by adults. Food shortage appears to be the most important factor. Nests and adult intraspecific aggression are additive to food shortage. In 19 years of monitoring on Arde, roseate terns failed almost completely during half of them. It is suggested that annual variations in breeding productivity may be the ultimate factor determining roseate tern turning of breeding and therefore productivity. Lack of predatory risk to drive prey to the surface may contribute to explain intermediate growth of food shortage. The postbreeding ecology of the Arde-Roseate Terns is unknown. The most critical parameters in need of research for this population are adult survival and recruitment rates. This is important in order to assess which are the main limiting factors: productivity or adult survival. Research into these areas remains the only way to formulate possible management decisions. Hopefully, the ringing scheme started in 1997 will elucidate this point.

Key-words: Roseate tern, conservation, monitoring, Arde, Sycilades.

Introduction

The roseate tern (*Sterna dougalii* Montagu, 1813) is an endangered seabird species with a world-wide distribution. The stronghold of this species is in the Indian Ocean (Gothfield 1983), but there are important populations in the United States, Europe (Ireland and the Azores Islands, Portugal), Australia (Great Barrier Reef), the Caribbean and Japan. The roseate tern has declined since the 1970s but numbers have stabilised recently. The declines in the North-American (Nisbet & Spindelow 1999) and European (Avery & del Nevo 1991) populations have been well documented, but the most abundant tropical populations have received little attention. In Europe it is classified as Endangered because of its large decline in numbers (Tucker & Heath 1994). The total world population is estimated at 20,000–30,000 pairs, of which 15,000–22,000 may be in the western Indian Ocean (Gothfield 1983). Very

It is known of this species in the Indian Ocean, apart from the population on Aride Island, Central Seychelles. Small roseate tern colonies were formerly scattered around Central Seychelles and in the Amirantes. Nowadays the only known colonies are on Aride and in the Amirantes (African Banks and Etiole, Foue, pers. comm., Skerrett 1996). The roseate tern on Aride (for some regarded as the subspecies *Sterna dougalii arideensis* (Warman 1979)) has been studied extensively and intensively since 1984. Reports with that information are kept on Aride Island, and the general office of the RSNC. The main aims of the research were to provide information on breeding numbers and productivity in order to identify possible limiting factors and avoid the conservation of the Aride population. Since 1997 detailed information on reproductive parameters has been collected, along with the several ecological factors that were likely to explain annual variation in breeding numbers and reproductive rates.

This paper summarises 19 years of roseate tern monitoring and research on Aride Island and its contribution to the conservation of this endangered species.

Methods

Breeding population estimates

The breeding population was estimated in 1975 and every year since 1984. Between 1984 and 1995 the breeding population was estimated without intrusion into the nesting areas. Counts of incubating birds were made before chicks started to hatch, from suitable viewpoints, walking around the edges of the colonies and/or from temporary hides (Ayrton 1993, 1994; Maal 1998; Bomler et al. 2002). Since 1996 all nests have been counted 18 days after the laying of the first egg, a method found feasible and applied in colonies in Europe and North America, in terms of reliability of population estimates and minimization of disturbance (Ratcliffe & del Nave 1995). Since 1997, two quadrats have been established (except in 2000) in the main colony, with corner posts and string. 16 days after the first egg was seen: one peripheral and less dense quadrat (49 m²) and one more central and denser quadrat (84 m²). The sample size for each quadrat was increased with adjacent nests. All nests in these plots were marked with numbered pegs and counted before and after the main count, in order to estimate the proportion of nests missed by the count. In addition, all nests in front of a permanent hide were mapped between 1997 and 1999, at the time of egg laying. The position of each clutch and the fate of eggs and chicks were monitored daily (Ramos 2001). This allowed to estimate the proportion of clutches lost prior to nest marking.

Reproductive parameters

Until 1996 chick survival and productivity (*n*^o of chicks fledged per breeding pair) were estimated from regular visits to viewpoints to count the number of chicks in sampling areas. At the end of the breeding season sampling areas and the rest of the colony were surveyed for dead chicks (Ayrton 1993, 1994; Maal 1998).

Since 1997 reproductive parameters have been studied in detail. During up to 30 minutes daily visits to the study quadrats and sub-colonies, eggs were measured (length and breadth), chicks were ringed and weighed at hatching and, thereafter, whenever they were encountered (Ramos 2001). Likely causes of chick mortality, notably intraspecific aggression by adults and infestation by ticks (*Dadhyausus dorsifoveus*) were recorded for chicks in the study quadrats and noted in a sampling area from a permanent hide (Ramos et al. 2001).

Fledglings have been ringed with metal rings (right leg) and special rings with four-character inscriptions (left leg) also used in Europe (Casey *et al.* 1995) and North America (Nisbet and Spenderon 1999). The special rings are made from incoley and can be read with a telescope at ranges of 15–25 m.

Ecological studies

Studies of nest-site selection, foraging habitats, diet, chick-feeding rates and impact of ticks on breeding success and chick survival were conducted between 1997 and 1999 (Ramos 1998a, 2000, 2001, 2002, Ramos *et al.* 2001).

Results

Colony size and distribution

Three main colony sites have been used regularly on Aride since 1984: The Lodge Glade, Bois Tortue and Western Woodlands (Fig. 1). The breeding population of the first two colonies has decreased gradually (the Lodge Glade is not used since 1993) and virtually all breeding birds are now concentrated in the Western Woodlands colony (Table 1). This colony comprises a main colony and small sub-colonies. In 1988 some of these groups were quite distant from the main colony (Fig. 1). Since 1997 there are only two groups, about 20–30 in distant from the main colony. Between 1997–2001 the number of breeding pairs of these two groups decreased markedly: (1) 12, 9, 3, 2, 2; (2) 6, 2, 0, 0, 1, which shows further the tendency for concentration of the breeding population into only one major colony.

In 1998 a new colony of 106 breeding pairs was established in the western woodlands rocks. This colony held 88 breeding pairs in 1999 but it was not used in 2000 and 2001. Otherwise irregular small colonies of up to 6 breeding pairs have been located on the western (Ramos 1997) and eastern (Hunter & Bradbury 2001) rocks. Overall, the breeding population crashed from 4,300–4,800 in the 1970s (Warman & Todd 1984) to about 1000 pairs in 1988. The estimate of 9000 breeding pairs in 1984 was considered unreliable by Bullock (1989).



Fig. 1. Distribution of regular colonies on Aride (Bullock 1989; Ramos 1999). LG= Lodge Glade, BT= Bois Tortue, WW= Western Woodlands. There has been irregular colonies on western (1998–9, Ramos 2002) and eastern sides (2000, Hunter & Bradbury 2001).

Table 1. Population estimates, date of first egg and breeding success for Roseate Tern on Arica between 1984-2001.

Year	No. breeding pairs per colony		Total population (breeding pairs)	Date of 1st egg	Breeding success (chicks fledged)	Ref
	Edge Glade	Islet Tortise				
1973			4,300 - 4,800			1
1984			5000 ^a	19 May (?)	Rising young	2
1985			No data	8 June	0	3
1986			2000-3000	19 May	0	3
1987	600	50	600	5 June	0	4
1988	550	30	500	12 May	75-150	4
1989	400	10	700	29 May	550-583	5
1990	500	25	750	28-29 May	316	5
1991	-	-	No breeding	No breeding	0	6
1992	170	10	420	4 June	25-30	6
1993	50	25	240	4 June	140	7
1994	0	22	404	19 May	203	8
1995	0	11	600	29 May	300	9
1996	0	13	1242	13 May	400-500	10
1997	0	7	843 (1106) ^a	3 June	< 10	11
1998	0	8	954 (1151) ¹	17 May	678-708	12
1999	0	4	1088 (1257) ²	14 June	0	13
2000	0	3	604 (1292) ²	3 June	15	14
2001	0	4	729 (837) ¹	16 May	170	15

References: 1 - Todd 1975 (in Bullock 1989), 2 - Tjornk & Volont 1984, 3 - McCarthy 1986, 4 - Bullock 1988, 5 - Castle & Miles 1991, 6 - Lardoux-Sam 1993, 7 - Aguirre 1993, 8 - Aguirre 1994, 9 - Masi 1995, 10 - Masi 1997, 11 - Ramon 1997, 12 - Ramon 1998b, 13 - Ramon 1999, 14 - Harter & Bealbury 2000, 15 - Ramon & Pacheco 2001
^a Estimate considered unreliable by Bullock (1989)

¹ Count adjusted for the number of nests missed in the main colony

² A new influx of birds appeared in early July. It was estimated that by then the number of birds in front of the permanent beds (the study area) doubled the number of birds present in June, so the estimate of about 1300 breeding pairs (Harter & Bealbury 2000)

Table 2. Correction of the Western woodlands main colony nest count since 1997

Year	N° of nests counted	N° of nests marked	% of nests missed	Mean % of eggs missed
1997				28.8
Quadrat 1	33	31	25.8	
Quadrat 2	54	79	30.7	
1998				20.9
Quadrat 1	15	17	10.8	
Quadrat 2	49	70	30.0	
1999				14.9
Quadrat 1	22	23	4.3	
Quadrat 2	52	70	25.7	
2001				12.4
Quadrat 1	6	8	25	
Quadrat 2	13	13	0	

In 1997 the breeding population of the main woodland colony was estimated with two methods: (1) walking around the edge of the colony and (2) a total nest count 18 days after the first egg was laid. Both methods produced similar figures: 800-900 vs 843. This gives support to the fact that population estimates between 1986 and 1995 were fairly accurate.

Between 14.9% and 28.8% of the nests were missed during the main count between 1997 and 2001 (Table 2). Roseate terns laid mostly in concealed sites and their eggs were well camouflaged amongst the leaf litter, which should account for the nests that were missed. Since 1997 two figures have been produced: a total nest count and an adjusted count for the number of eggs missed (Table 1). The first figure should be more comparable with previous estimates.

Colony and nest-site selection

Arde is the only location in the world where roseate terns are known to nest under a tree canopy (the sooty tern *Sterna fuscata*, the most abundant ground-nesting seabird on Arde also nests under the tree canopy, unlike in other areas throughout its range (Fearn et al. 1997). In the 1980s, about 50% of the roseate terns nested in an open area, the Lodge Glade, but this colony was abandoned in early 1990s (Table 1). This abandonment was partially blamed on the growth of *Arctostaphylos* sp., a herb that densely carpeted the area, entangling both adults and chicks (Ayrton 1993). Despite clearance of *A. arctostaphylos* the birds abandoned this colony in 1993, following two years of null breeding success (Ayrton 1993, 1994). Since 1994 no adults have been observed investigating this colony and the area is now occupied by sooty terns.

The two main woodland colonies, Bois Tortue and Western woodlands are fairly isolated from sooty tern breeding areas. The colonies established by roseate terns on the western roosting rocks in 1998 and 1999 were on the edge of areas occupied by sooty terns. Altogether these observations suggest that roseate terns may avoid areas with sooty terns.

Within colony-sites roseate terns select concealed nest-sites: closer to rocks or logs than random points (Ramos 1998a). Concealed sites, especially those with overhanging rocks, appear to protect chicks from attacks of adults and kleptoparasitism (Ramos 1998a).

Predation

Arde Island is secure from predation by mammals and mainland-based birds. Rats were never recorded on Arde. Goats, cats, dogs and pigs were present on Arde during the XX century (Worman & Todd 1984) but their effect on the Roseate Terns was not documented. In the 1980s and 1990s the only predators recorded were Barn Owls *Ninox alba* (introduced from South Africa to the Seychelles): which were recorded to kill up to 18 adults in 1996 (Mau 1998). Active management reduced Barn Owls to a few adults (Betts 1998, Bowler and Harrier 2001) and virtually no Roseate Tern adults have been predated since 1997.

The sticky *Pinna grandis* seeds have also been responsible for the death of some adults in certain years, when breeding coincides with heavy fruiting, such as in 1994 (Ayrton 1994).

Diet and foraging habitats

Rosate Terns are specialised predators on small schooling fish. Goatfish (Mullidae; *Parupeneus* or *Micropodichthys*) comprised over 90% of all prey deliveries to chicks from 1997 to 1999 (Ramos 2000). In both 1997 and 1998, periods of good food supply, were interrupted by one period of low food delivery, lasting up to two weeks in 1997. During these periods alternative sources of food were apparently scarce (Ramos 2000).

During the 1998 successful breeding season, Rosate Terns foraged within dense flocks of lesser mudflats (*Anas aethiops*), which in turn were associated with predatory fish. roscate tern feeding flocks over predatory fish were significantly larger, with individual birds increasing significantly their foraging attempts than those birds in the absence of predatory fish (Ramos 2000). During the 1999 failure season, most roscate tern flocks were either monospecific or mixed with fairy terns, and no dense feeding flocks or activity of predatory fish were detected (Ramos 2000). As a consequence, food shortage in 1999 may have been more general: it could be related to the death of the coral reefs, which, in turn, could be responsible for a poor recruitment of mudflats.

In 1998 virtually all feeding flocks were multispecific and were over blue-water > 200 m from the coast. In contrast, in 2001, although feeding flocks were not recorded systematically, many roscate tern flocks were monospecific and were observed < 200 from the coast (at least on 6 days birds were feeding on the break of the waves, diving in water of 10–20 cm deep). It must be noted that clupeoid fishes (Clupeidae and Engraulidae) comprised an important proportion of the diet in 2001 (Ramos & Pecheco 2001). The size of non-mudflats taken in 2001 (and therefore their profitability) were much larger than those of mudflats, and, apparently, some adults specialised on their capture. Large multispecies feeding flocks over predatory fish in 2001 seemed much less common than in 1998.

Factors influencing breeding success

Three main factors affect roscate tern breeding success on Aride: (1) food shortage, (2) tick infestation and (3) intraspecific aggression by Roscate Tern adults on chicks (Ramos 1997, 1998b, 2000, 2001, Ramos *et al.* 2001). The first factor is by far the most important, the other two factors being dependent on the extent of food shortage. In 19 years of monitoring on Aride, roscate terns failed almost completely during half of them (Table 2). Table 1 clearly shows that breeding failures are connected with later breeding. Even during early breeding years such as in 1998 there are periodic food shortages (Ramos 2000, 2001). The main factor limiting hatching success is food shortage. In years, such as in 1997, when eggs are left unattended for long periods (over ½ h) they may be rolled by Wright skinks (*Molura wrightii*) until they break against a rock (Ramos 2001, Maul 1998). Otherwise, no other type of egg predation has ever been recorded. Therefore, although Wright Skinks are the proximate cause of egg predation, the ultimate main factor appears to be food shortage, which must explain high rates of eggs unattended by adults in certain years.

Before periods of food shortage chick growth was correlated with egg size, suggesting that, if food is abundant, intrinsic factors (parental "quality") are the primary determinants of chick growth and survival (Ramos 2001). However, since 1997 food shortage has severely limited chick growth in 3 of 4 years of a chick growth study (Ramos 1999, 2001, Ramos &

Pacheco 2001) and should explain the almost complete breeding failures registered in 10 of 19 years of monitoring on Aride (Table 2). Lack of predatory fish to drive prey to the surface (Ramos 2000) may contribute to explain intermediate periods of food shortage. However, Ramos *et al.* (in prep.) showed that breeding failures are connected with later breeding, which, in turn, might be a consequence of a food supply reduction in certain years.

Tick infestation and adult intraspecific aggression limit also chick survival but are additive to food shortage. During periods of food scarcity ticks speed up chick mortality (by exsanguination and possibly through diseases transmitted by tick-borne viruses; Ramos *et al.* 2001) and newly hatched chicks are more prone to attacks of adults (Ramos in prep.). In 1998 it was estimated that ticks and intraspecific aggression alone were responsible for the death of 24.3% and 8% of the chicks, respectively. Ticks may also influence post-fledging mortality, because nestlings infested with ticks fledge later (and presumably in poorer condition) than noninfested chicks (Ramos *et al.* 2001).

Productivity (chicks raised per pair per year) is the product of four variables: clutches laid per year \times clutch size \times hatching success \times chick survival. Breeding has occurred mainly in certain years of early breeding such as in 1988 and 1994 (Table 1). Presumably birds that fail the first breeding attempt (in 2000 a new influx of breeding birds appeared on Aride one month after the beginning of the breeding season, Hunter & Bradbury 2001) remain if food conditions do not deteriorate or improve visibly. Mean clutch size varies among years from 1.03 to 1.55. This variability may depend on food availability early in the breeding season and the timing of breeding (Table 1).

Discussion

Limiting factors

The monitoring and research results clearly indicate that food shortage is the main factor limiting roseate tern breeding success on Aride. Early reports (McCarthy 1986, Bullock 1989) suspected that disturbance could have strong adverse effects on breeding success, but careful monitoring and research activities conducted on Aride (Ramos 2001) and elsewhere (Nisbet 1981, 1989, Gochfield *et al.* 1998, Nisbet & Spenslow 1999, Zings *et al.* 1997) do not have a significant impact on roseate tern productivity.

The reasons behind the frequent food shortage appear to be related, at least in part, to the specialised foraging behaviour of the roseate terns. They are specialised on factors that make prey available to them, especially predatory fish, although wind strength, upwelling and marine currents may also be relevant in certain years or periods within a year (Shealer 1996, Ramos 2000, Ramos & Pacheco 2001). Aride roseate terns have developed adaptations to breed under stressful conditions, especially the fact that they seem to sacrifice clutch size and/or egg size for early laying (Ramos 2001, 2002). This suggests that food scarcity is not a recent factor affecting roseate terns, but, instead, appears to have been an important historical factor shaping evolutionary breeding adaptations.

The negative correlation between the multivariate El Niño index and timing of breeding suggests that oceanographic variables over a relatively larger scale influence the timing of reproduction (Ramos *et al.* in prep.). Moreover, the size of the breeding population was inversely correlated with sea-surface temperature. Since high sea-surface temperatures are connected with low productivity (this means that annual variations in marine productivity may be

the ultimate factor determining rookery term timing of breeding and, therefore, productivity (Ramos *et al.* in prep.). The influence of oceanographic conditions on adult survival is unknown. The underlying causes of definite periods of food shortage within a breeding season are partly unknown and difficult to predict. Information on the ecology and movement patterns of predatory fish around Aride is necessary to fully assess and predict the impact of predatory fish on food availability. Aride rookery terns seem to rely heavily on Mullidae (although other schooling fish are readily taken if available, Ramos & Pacheco 2001) so it would be important to investigate the factors that influence recruitment of mullets.

For the Northwest Atlantic population the main factors limiting the rate of increase seem to be demographic; especially low annual survival rate and probably a low survival between fledging and first breeding (Spendslow *et al.* 1995). Studies of demographic parameters for the Aride population have only just begun. Fledglings were tagged in 1998 and 2001. Some of those ringed in 1998 returned to Aride in 2000 and 2001, so an effort to read the Roseate Tern special rings in future years is necessary in order to obtain information on recruitment rates and adult survival.

The strong annual variation in breeding numbers (Table 1) mean that there may be movements between colonies in the Indian Ocean or that some adults decide not to breed in certain years. The sudden influx of new breeding birds in 2000 (Hunter & Bradbury 2001) gives some support to this idea. Altogether this means that the study of demographic parameters must be viewed as a long-term study. The strong population crash between 1991-1993 parallels the crash of the rookery tern regional population in North America (Nisbet & Spendslow 1999). Therefore, the possibility that major changes in weather or oceanographic patterns may influence rookery terns on a global scale should be considered.

Most of the annual mortality of adults occurs after they leave Aride, but the postbreeding and migratory ecology of the rookery terns in the Indian Ocean is unknown. Hopefully the ringing scheme started in 1997 will shed some light on the postbreeding quarters of the birds.

Conservation and research

The research conducted on Aride-Roseate Terns has provided rigorous ecological information to serve as the basis for management planning. It was demonstrated that food shortage is the main factor limiting productivity. However, the factors that may enhance food availability are complex (involving underwater predators, physical oceanographic features of the ocean and, perhaps, prey recruitment) and not liable to any immediate management action. A possible link between tern landings and mass movements in the Seychelles bank, and Roseate Tern breeding success should be researched.

Although food supply is the main determinant of productivity, nothing is known of adult survival. The fact that productivity has been low means that for the maintenance of a stable population adult survival and longevity must be relatively higher. In temperate populations, productivity is high and adult survival is low, relative to those of other long-lived seabirds (Spendslow *et al.* 1995). Thus, management actions of temperate populations should be focused on actions to enhance survival, rather than on actions to enhance productivity (Nisbet & Spendslow 1999), but, at the moment, it is difficult to envisage any suitable management actions that would enhance survival of a long-lived migratory seabird whose postbreeding ecology is virtually unknown. Research into these areas remains the only key to

formulate possible management decisions.

Management actions to maintain and/or enhance suitability of colony and nest-sites (keeping open fly-ways through the forest canopy, adding stones and/or logs that may attract breeding birds to certain areas of the colony and/or prevent attacks of adults on chicks) can be carried out, but their overall impact on productivity is likely to be small (Ramos 1998a, 1998b, in prep).

The most critical parameters in need of research, adult survival and recruitment rates, require a "hands-on" study (Nisbet & Spandelow 1999). Tropical roseate terns are more sensitive to disturbance than their temperate counterparts (Ramos 2001, in prep.), but with appropriate precautions, especially the construction of shelters for newly hatched chicks, nestlings can be ringed and weighed with minimal adverse effects (Ramos 2001). The acquisition of knowledge on these parameters will take a very long time if only chicks are ringed, because of the frequent breeding failures. Apart from one adult entangled with a string, breeding adults have not yet been ringed. Unlike their temperate counterparts they do not leave hatching eggs or newly hatched chicks and could be caught by hand at the appropriate time of the breeding season.

Finally, the knowledge acquired from the research on Aride Island may have important implications for the conservation of the roseate tern throughout the tropics.

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Investigations into the occurrence of a previously unrecorded ghost crab (*Ocypode rydleri*) in the Seychelles region

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Abstract: Previous studies on ghost crabs in the Seychelles region have only described two species, *Ocypode cordimana* and *O. ceratophthalma*. Crab fall trapping on Cousine Island has revealed the presence of a third ghost crab species, *O. rydleri*. As this species was not found on the island in previous studies, it is believed they have only recently colonised it. *O. rydleri* are found mainly on the exposed northern beaches of Cousine, and appear to have seasonal variations in their behaviour and distribution. *O. rydleri* are on average larger than the other ghost crab species, and as yet, no juvenile specimens have been obtained. Further investigation is required to understand *O. rydleri* ecology in the Seychelles, and to determine its range within the region.

Keywords: Decapoda, distribution, abundance, colonisation, Cousine island

Introduction

In the economy of a coral island, no group of animals is of greater importance, from a biological point of view, than the land Crustaceans (Haig 1984). The smaller granitic islands of the Seychelles such as Frigate, Anse, Cousine, Rocif etc. have more in common with the coralline 'outer islands' than with the main habitats of the granitic islands (Procter 1984). Ghost crabs (genus *Ocypode*) are the most abundant macro-invertebrates inhabiting the sandy beach of Cousine Island. They play an important role in the ecology and food chain of the sandy beach habitat (Jackson *et al.* 1991) and are thought to play a critical part in the energy transfer between terrestrial and marine ecosystems (Alexander 1979). These crabs occupy the role of both predators and scavengers (Haig 1984) and so are crucial to the balance of the islands ecology.

Historically, investigations and literature on ghost crabs in the Seychelles described two species. The horned ghost crab (*Ocypode ceratophthalma*, Pallasi) is conspicuous by having plumes or horns above its eyes and a pale green colouration (Anderson 1994). The other ghost crab commonly described for the region is the dark ghost crab (*Ocypode cordimana*, Desmarest). This crab is characterised by its steel grey to pale buff colouration, lack of horns (Grubb 1971) and robust build (Anderson 1994). Grey and pink ghost crabs observed on the beaches of Cousine were initially presumed to be diverse colourations of the same species (*O. cordimana*), however, on closer inspection, a number of morphological and behavioural differences were noted between the two.

After active crab sampling resulted in the capture of both forms in fall traps on several occasions, it was decided to investigate the phenomenon more intensively and determine conclusively whether the two crabs were different morphologies of the same species, or different species altogether. Subsequent to species clarification, it was decided to investigate the characteristics and appearance of the recently discovered crab species in the region.

Materials and Methods

All investigations on ghost crabs were carried out on the sandy beach of Cousine Island, which is approximately 960 m long. Markers numbered 0 (South) to 30 (North) were positioned on the apex of the dune, marking off 30 m stretches of beach (Ditchins *et al.* 1999). The distance between markers 29 and 30 is approximately 28 m. Fall traps (10 L buckets) were placed at the base of the dune at each marker, and were baited with fish, minced beef or dead crabs. Markers 0–29 were sampled simultaneously for five consecutive nights. Marker 30 was not sampled as the at high tide, the whole dune is submerged. Two sample runs were carried out per month. The first sample was carried out at spring tide and the second at neap tide. All trapping took place between May 2001 and March 2002 (No trapping took place in August or July 2001).

Crabs caught in the traps were measured (all crab sizes listed below are carapace width, except where specifically stated otherwise), and sexed. All crabs were numbered on their carapaces using a permanent marker pen or correction fluid and then released at the point of capture. This ensured that recaptures could be identified as such, and as overestimates of the population could be avoided.

When pink or grey crabs were caught, the two were studied together to look for any obvious morphological differences. Samples of the pink crab were also sent to both the Oceanographic Research Institute (Durban, South Africa) and the Council for Scientific and Industrial Research (Pretoria, South Africa) for independent identification. Both crab types were observed when foraging or moving on the beach to distinguish any behavioural differences.

Results

Independent identification from both expert sources confirmed that the pink ghost crab was in fact *Oryzodendrydri*. Kingsley. An observational description of both *O. rydleri* and *O. cordimana* was carried out (Fig. 1).

Oryzodendrydri

These crabs have a distinctive pale pink carapace fading into cream at the anterior edge behind the eyestalks. The merus is pale pink at the edges fading into cream at the centre. The water segments of the legs are cream. All joints displayed maroon to dark red coloration. The propodus are completely absent of hair (Fig. 2). The chelipeds are highly granular with a row of about 10 dark granules on the palm of the large chela (molaratory organ) (Fig. 3). The eyes are pale grey or green at the base, darkening to dark blue/grey or green at the top. The eyestalks are pale pink and extend past the compound eyes to terminate in conspicuous pink "caps" (Fig. 4). The anterior margins on the dorsal side of the carapace are sharply pointed and raised. Foraging occurs mainly at the intertidal or low tide level.

Oryzodendrydri

The carapace is dark grey or pale buff with brown patches. All the segments of the legs fade from dark grey or buff to light grey or buff at the edges with patches of red/brown. The joints of the legs are also a red/brown colour. The propodus of each leg has a brush of fine hairs on their inner edges (Fig. 5). The chelipeds are mildly granular on their outer sides

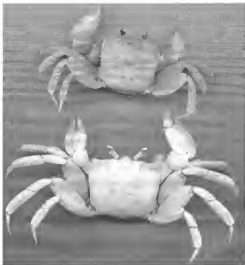


Fig. 1. Adult male *Oryzopsis cordimana* (top) and *O. ryukyu* (bottom)

but smooth on the palms of both chelae (Fig. 6). The eyes are almost uniformly grey/black, although slightly darker at the top. The eyestalks extend marginally past the compound eyes, but are less prominent than those in the *O. ryukyu*. The eyestalk "cap" is a dark grey to black colour, very similar to the colour of the eyes (Fig. 7). The anterior of the carapace is mildly pointed and curved upwards. Foraging occurs mainly at the high tide or dune crest level, and many individuals are seen foraging inland.



Fig. 2. Propodi of *O. ryleri*



Fig. 3. Propodi of *O. cordisawa*

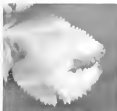


Fig. 4. Large chela of *O. ryleri*

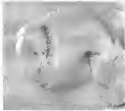


Fig. 5. Large chela of *O. cordisawa*



Fig. 6. Eyestalks of *O. ryleri*



Fig. 7. Eyestalks of *O. cordisawa*

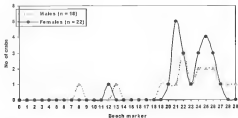


Fig. 8. Distribution of *Ocypode rydersi* caught in fall traps on Cousine Island beaches (April 2001–March 2002) (from south to north)

Abundance and Distribution

Fewer *O. rydersi* were observed during the South East monsoon season than during the North West monsoon. In total, 40 *O. rydersi* were caught on Cousine during the study period. The majority of individuals were caught on the northern beach, although very few at the far northern extremity (Fig. 8). A very small amount were caught South of marker 15.

O. rydersi were found to be larger than the other ghost crab species on average, and no individuals less than 38 mm carapace width were recorded (Fig. 9). There was no significant difference between the number of males ($n = 18$) and females ($n = 22$) caught (χ^2 , $P > 0.05$). No mating of any sort was observed for this species although female *O. rydersi* in berry were seen spreading eggs in the ocean in early June. No *O. rydersi* were caught in traps during the day, although they were often seen foraging along the tide level at this time.

Discussion

Although *O. rydersi* has a known distribution from the western Indian Ocean to the western Pacific Ocean (Richmond 1997), it has not been recorded in the Seychelles region before (J. Gerlach *pers comm.* 2002). Previous investigations on Cousine and other islands in the region described the presence of only the dark ghost crab (*O. condonensis*) and the horned ghost crab (*O. corotophthalmus*) (Grubb 1971, Haig 1971, Alexander 1979, Wood 1986, Anderson 1994, Hitchins *et al.* 1999, Hitchins *et al.* in prep). It seems that *O. rydersi* was absent from the beaches during crab sampling carried out around turtle nests on Cousine Island between 1995 and 2001 (P. Hitchins *pers comm.* 2001). This is interesting, as it would suggest a recent colonisation of the island and possibly the region as well.

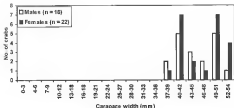


Fig. 9. Size distribution of *Gecapodes ryderi* caught in fall traps on Cousine Island beaches (April 2001–March 2002).

Evidence for recent colonisation is partly supported by the low numbers of *O. ryderi* on the island relative to the other two ghost crab species. From personal observation, it would appear that the numbers have increased slightly over the last year, but this trend could be purely seasonal. The increased number of crabs observed during the North-West monsoon may be due to the ghost crabs tendency to stay in their burrows during the winter or dry season (Jackson *et al.* 1991).

O. ryderi distribution being most concentrated north of marker 15 could be due to the preference *O. ryderi* has for exposed beaches (Jackson *et al.* 1991, Branch *et al.* 1994). The northern beach between markers 13 and 25 is highly exposed due to its curved shape. The northern extremity, where few *O. ryderi* were found, is protected by rocky outcrops that protrude out to sea, and so is considerably more sheltered.

The large size of *O. ryderi*, relative to other ghost crabs was not unexpected, as they are documented as being larger than the other two species (Richmond 1997). It is, however, interesting that no juvenile specimens were found. This phenomenon requires further investigation.

O. ryderi showed no predominance of either sex, probably due to their range being restricted to the sandy beach (Jackson *et al.* 1991). This is in contrast to *O. coxcombata* that showed a strong male bias, as the females tend to burrow inland (Grubb 1971), but the traps sampled only the individuals present on the beach. Due to the scarcity of reproductive observations, it was difficult to determine a clear breeding season. In South Africa, breeding takes place in summer, and females in berry are usually sighted in February (Jackson *et al.* 1991). In the limited observations in this study, most gravid females were found in June, which is the dry season. Further investigations are required to accurately determine *O. ryderi* reproductive behaviour.

It was interesting that no *O. ryderi* were caught during the day, however, as the traps were set at the base of the dune, and the crabs foraged mainly at the tide level, it is probable

that they simply weren't in the region of the traps at this time. Night catches could be a result of crabs being attracted to the scent of bait in the traps as they returned to their burrows higher on the beach (pers. obs.).

The crab species of the Seychelles islands have received only cursory attention from scientific investigations, and so the presence of a previously undescribed species for the region is not astounding. The fact that no *G. rjabovi* were found in previous studies on Cousine is interesting and would suggest recent colonisation of the island by a third ghost crab species. Further study on other islands is crucial in order to determine the extent to which colonisation has occurred.

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that they simply weren't in the region of the traps at this time. Night catches could be a result of crabs being attracted to the scent of bait in the traps as they returned to their burrows higher on the beach (pers. obs.).

The crab species of the Seychelles islands have received only cursory attention from scientific investigations, and so the presence of a previously undescribed species for the region is not astounding. The fact that no *O. nycteri* were found in previous studies on Cousine is interesting and would suggest recent colonisation of the island by a third ghost crab species. Further study on other islands is crucial in order to determine the extent to which colonisation has occurred.

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Habitat use by the Seychelles fineline damselfly (*Tetraneura affluens*) on Silhouette island, Seychelles

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Abstract The Seychelles fineline damselfly, *Tetraneura affluens* was collected in 1909 and then not until 1997 when it was rediscovered on Mahé and subsequently on Silhouette. In 2002 research on Silhouette located four sites for the species providing new data on appearance, vegetation use by juveniles and adults, colour development, egg laying. Apparent preferences for open vegetation (*Clitoraria detrita* and *Paraserianthes falcataria*) is attributed to males preferring an open vegetation structure.

Key words: *Clitoraria*, conservation management, *Clitoraria*, *Paraserianthes*, structure

The Seychelles fineline damselfly *Tetraneura affluens* (Martin, 1896) was collected by the Percy Sladen expedition of 1918 (Campion 1913). It was thought extinct until 1997 when it was rediscovered on Mahé 1997, with subsequent sightings on Silhouette (Santways 2001). The species appears to be very restricted and little is known of its biology. Between March 9th and 16th 2002 research was conducted on Silhouette on behalf of the Nature Protection Trust of the Seychelles (NPTS) with the aim of determining some of its ecological requirements and conservation needs. The main focus of research was to determine the distribution of *T. affluens* on Silhouette, provide a description of the sites, identify any vegetation preferences and collect any information relevant to the conservation of the species.

Methods

Searches were made for *T. affluens* at all sites where the species had been observed in 1997-2001. All located populations were observed for 3-6 hours and notes made of all interactions and movements. The habitat characteristics of each site were noted. The area of habitat used was estimated in order to provide approximate population density calculations.

Results

T. affluens was easily recognised in the field by its extremely slender abdomen and distinctive red colour, this does not appear to have been recorded previously. The female is a duller shade of red than the male.

Population and Distribution

Three previously reported sites were confirmed, Grande Barbe, the pool near Belle Vue and the clearing at Belle Vue. The site named 'Belle Vue extra' was on the other side of the clearing at a sufficient distance to warrant a separate record. A fifth unexplained site, at the north western end of the settlement at Grande Barbe is similarly isolated and classed as a distinct site (see Fig. 1).

Numbers recorded at each site and estimated population densities are shown in Table 1. In total 31 individuals of *T. affinis* were observed. In addition, Justin Gerlach also noted *T. affinis* at a separate location at the other end of Grande Barbe. Due to time constraints, it was not possible to investigate this sighting further and it is not included in this analysis. A breakdown of these figures shows many more males than females were recorded at the sites (12:4 of the sexed adults).



Fig. 1. Distribution of *T. affinis* on Silhouette island, filled circles - 2002 records, open circle - pre-2002 (Mare aux Cochons 1908; Anse Patache 1997)

Table 1. Population data for the four main sites

	adult			juvenile			snout-vent length
	male	female	?	male	female	?	
Grande Barbe	4	1	8	0	0	0	0
Belle Vue pool	3	2	0	1	1	1	1
Belle Vue clearing	3	1	0	0	0	4	0
Belle Vue extra	2	0	0	0	0	0	0

	area (m ²)	density (1/m ² per individual)		
		male + female	male, female + juvenile	male only
Grande Barbe	100	7.7	7.7	23
Belle Vue pool	20	4	3.5	6.7
Belle Vue clearing	60	15	7.5	20
Belle Vue extra	9	4.5	4.5	4.5

Table 2. Habitat selection according to selected criteria

	distance to water	water flow	breeding evidence	<i>Chironomus</i> present	<i>Chironomus</i> structures	overhead shade
Grande Barbe	30m	Medium to slow	No	Yes	Closed and Varied	Light
Belle Vue pool	0m	Slow	Yes	Yes	Open and Varied	Medium
Belle Vue clearing	30m	Slow	Yes	Yes	Closed and Varied	Light
Belle Vue extra	5m	Zero	No	Yes	Closed and Varied	Light

The site areas vary from 9m² for the Belle Vue Extra to 100m² for Grande Barbe and the area per individual also varies from a low of 2.5m² for the Belle Vue pool to 20m² for the Belle Vue clearing. When all adults are included all the sites show densities of less than 8/m² per individual. Figures for Belle Vue pool males are probably the most accurate given the physical location of the site. Therefore 3 males in an area of approximately 3x4m can be seen as more reliable as an indicator of population density. Note, however, the relatively closed territory which may be unique. Lower male densities for other sites may be due to their openness. The Grande Barbe male densities were based on cautious counting of males and the actual territories could be much smaller than suggested with possible densities being higher.

Habitats

The sites can be analysed according to certain criteria as summarised in table 2. Common factors of all the sites are the presence of slow to medium flowing water within 30m, *Chironomus* *lutea* present with an open or varied structure and light or medium shade.

There seems to be a relationship between the levels of light and the structure of *C. lutea*. The amount of shade provided by the canopy trees determines the growing structure of

the plant below (Begon *et al.* 1996). The light shade given by the albizia trees (*Paraserianthes falcataria*) allows *C. hirta* to develop a varied structure typified by a series of open landing sites at all heights. These open landing sites were too sparse in deep shade and become closed off due to excessive leaf growth in full sun. The majority of the interaction noted in all sites was in, on and around the open and varied structure given by *C. hirta* underneath light shade from trees such as albizia. Few other trees gave the same shade. *C. hirta* grows all over Silhouette under a range of trees, but its structure is rarely as suitable for *T. affinis* as that growing under the light shade afforded by the albizia.

C. hirta was present and used as a scuffling location at all sites. Other shrubs were present at all sites but only settled on at two. Light shading trees are present at all sites. Where present, agricultural plants were also used but not as frequently, and only as a temporary landing site. The structure of the various floral species was very different, giving further indications as to why *C. hirta* was preferred over the other available species. Cassava (*Manihot esculenta*) was scarce, had fewer landing places and those used were above 2 m in height. *Asystasia* sp. occupied a similar distribution to *C. hirta* under light albizia shade but did not have as many open landing sites. The leaves tended to be less supportive and were angled less rigidly and more downward sloping than *C. hirta*. *Nephrolepis baserana* ferns largely presented a closed structure, but when used it was on parts with a more open structure at lower heights typically 0.5 m, before the leaf structure closed off possible landing sites.

Life history

No courtship behaviour prior to mating was noted. Mating was not seen, but egg depositing in tandem was observed for over 2 hours in two different locations 30 metres apart, although the same pair being responsible for both events is a possibility. A range of 'C' shaped abdominal contortions was noted as the female moved her ovipositor into suitable positions for egg laying.

The sites used for egg laying were described as, damp rotting vegetation, damp vegetation, damp leaf litter, damp litter, underneath of root, damp vegetation, root, twig, damp sand, damp soil. In all cases there was a strong preference for damp conditions.

A nymph collected from Belle Vue pool and hatched by Ron Gerlach died emerging. The colour of the female terminal developed within 24 hours to a pale red. Corbet *et al.* (1969) estimated 10% of nymphs died in this way. The terminals emerged and flew into the trees around the pool. Their resting heights were 3m, 4m and 6m. These are all much higher than the usual resting heights for all other observations.

Interactions

The open and varied structure of *C. hirta* was used as the site for most of the observed interactions. All observations were of male-male and tandem pair- male interactions.

Movement occurred at a variety of heights, depending on the conditions found at each site. Flying heights at Grande Barbe were typically between 0.5 metres and 1.5m, Belle Vue Pool was similar but more frequent at lower heights, Belle Vue Clearing was 0.5m to 1.5m and the Belle Vue Extra site higher at 1.0m to 1.75m. These were all below the height of the *C. hirta* (2.0-3.2m). Movements were made through, and not over, the vegetation (only possible with the open structure of *C. hirta*). Male-male interaction was restricted to one

male 'buzzing' another male with no females present. Tandem (male and female flying as a pair) acting aggressively towards a second male were initiated by the male of of the tandem pair once and by both male and female twice. A tandem pair landed 23m from a second male whilst searching for an oviposition site. Teneral appeared to avoid interaction by flying away from male territories. No inter-specific interactions were noted.

Discussion

Each of the five sites was within 30m of an area cleared or previously cleared for the planting of agricultural plants. Perhaps clearing native forest creates higher light levels, which allows temporary colonisation by *C. hirta* and the development of a habitat for *T. affinis*. *C. hirta* is known to have colonised much of Silhouette but rarely grows under light shade.

Some individuals may have been counted more than once in the present study, even though attempts were made to do 'clean sweeps' of areas, counting all individuals within a short space of time to minimise the problem. The variation in population density estimates may suggest that these are inaccurate. The Belle Vue Pool site was a closed, easily observed area. Combined with known territory-holding behaviour of the male, it should represent a reasonably accurate estimate of the number of male territories in such an area. Observations suggest that this area supported one male in the pool territory, a second flying to the Belle Vue clearing and a third non-territorial interloper, with a total male density for the Belle Vue pool of one per 20m². Although this would seem to accord more with the figures for Grande Barbe and the Belle Vue clearing, this would seem to be a minimum estimate. Fewer females were observed than males at all sites. Possible explanations for this may include females spend most time away from these sites and visit to breed or there may be a biased sex-ratio.

Egg laying observations recorded that oviposition (or investigation) always occurred within 30cm of free flowing water, irrespective of whether or not surrounding vegetation lead into the water. Probing usually (but not always) occurred in damp matter. If conditions were dry there appeared to be probing on the underside, where damp soil could be reached. There was a general preference towards mossy area of roots and twigs. Leaf litter with egg laying sites were collected and analysed under a microscope but no eggs were found on the surface. Zygoptera often deposit their eggs endogenously (Longfield 1949). If this is the case with *T. affinis* eggs may have been overlooked in the plant tissue.

Nymphs need relatively clean water in which to catch prey and grow, although it is not known how long the nymphal stage takes. This information could be vital if a link is to be made between permanence of pools, creation of ponds and the seasonality of rainfall. How the rainfall regime affects all the sites over the whole of the breeding season will also be relevant to the egg laying of the adults. Observations indicate a range of sites used from dry to damp, but whether this is a condition maximising strategy or if all sites become damp is not known. The length of the breeding season and stages of development are also unknown.

The rate of colour formation of newly emerged teneral could be within 24 hours. If the rapid colour development of the female teneral is typical and not accelerated by the stress of unsuccessfully struggling to become free of its exuvia, then the observed pale female forms being mated could be less than 24 hours old. This would accord with the findings that they stayed close to the site of emergence and were mated soon after. No observations were made for female territories, so it is not known if females hold territory, the extent of their foraging

or their mating patterns. Tenebrals use high vegetation in immediate vicinity of convergence sites. Close proximity to slow flowing water and lightly shaded *C. hirta* appear to be the principal factors determining presence and distribution of males and breeding sites.

Perferential use of *C. hirta* as a resting place by *T. affinis* is due to sunlight being able to penetrate to parts of the plant, a range of suitable landing sites at heights of 0.5-2.0m. The open leaf structure provides landing and displaying sites, sufficient gaps between plants allows flights between sites and 'valleys' between plants allow territorial disputes to take place. There seems to be a very strong preference for *C. hirta* for male territory holding. Where these coincide with the presence of suitable water, it also becomes an egg laying and nymphal habitat. The interaction of tree shade and light levels on the structural growth of *Choleva* would seem to determine the existence of this habitat. *Albizia* and *C. hirta* are both non-native to Sifhuetie and both are regularly cut and cleared.

It is essential that further research be conducted to build up a more complete life history, exploring new sites and conducting a more lengthy study of the interaction between *Choleva hirta* and *Tenebralis affinis* if it is to stand the best chance of long-term survival.

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Reptile mark-recapture trials using rainforest plots at Montagne d'Ambre, Madagascar

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Abstract: Three plots (50 x 100 m) established in primary rainforest (600–1130 m elevation) were intensively searched at two or three nights for chameleons, geckos, and snakes at Montagne d'Ambre, in northern Madagascar. A total of 446 captures were made for eight geckos, eight chameleons, and three snakes belonging to the following genera: *Gehyra*, *Gehelobates*, *Gehelobates*, *Lepidobatrachus*, *Phelsuma*, *Pseudoeurycea*, *Uroplatus*, *Chamaeleonidae*, *Basiliscus*, *Coleonyx*, *Pseudocoleonyx*, *Crotalus*, *Atheris*, *Gerrhonotus*, *Lygodactylus*. Nightly capture success ranged from 43–79 individuals, indicating that plot searches of this scale may have applications for long-term monitoring. Chameleon movements recorded during the study showed that plot populations cannot be considered closed, and recapture success was too low to allow population size to be measured for most species. Obvious differences in species composition of *Basiliscus* and *Pseudocoleonyx* were found on opposite banks of a small river (one to five metres wide), suggesting that rivers of relatively small size can affect dispersal in these groups.

Key words: Chamaeleonidae, Colubridae, Ophiophagus, methods, reptile

Introduction

The endemic fauna and flora of Madagascar is considered a global priority for conservation due to the 'megadiversity' of the island and the ongoing loss of natural habitats (Myers *et al.* 2000). Aerial photographs and satellite images taken between 1950 and 1983 reveal that 50% of the remaining rainforest was destroyed during this period (Green and Saxena 1990). Half the Malagasy endemic vertebrates are rainforest amphibians or reptiles, and virtually all these species are restricted to native forest. As the rainforests become increasingly fragmented, isolated herpetological populations will decrease in size until eventually some populations will no longer be viable. The commercial collecting of some Malagasy reptiles such as geckos (*Phelsuma*, *Uroplatus*) and chameleons (*Basiliscus*, *Coleonyx*, *Pseudocoleonyx*) may also have a negative impact on some populations. However, to date, no detailed population studies have been reported for any rainforest amphibians and reptiles in Madagascar, and field techniques for calculating densities remain largely untreated (the one exception being distance sampling with *Coleonyx* chameleons, see Brady & Griffiths 1999).

We here examine the potential of using nocturnal searches of rainforest plots, to determine population data for reptiles. Sampling at night has the advantage that diurnal geckos and chameleons can be found roosting, while nocturnal geckos and snakes are active and typically obvious. This study was made at Montagne d'Ambre during a herpetological survey of the region (Raxworthy & Nussbaum 1996).

Study area

Montagne d'Ambre, centered at 12°32'S, 49°10'E, is a mountain range with a north-south orientation at the extreme northern tip of Madagascar (Fig. 1). This mountain range is also referred to as Ambohitra on modern Madagascar maps and as Amber Mountain on English maps of the last century, but both these names are rarely used. The highest peak is at 1475 m elevation, with the base at 200–300 m.

Montagne d'Ambre has a distinctive microclimate. The annual precipitation (e.g., Station Roussettes, mean 2378 mm) is much higher than the surrounding region (e.g. Antsiranan, mean 960 mm) (Néel & Laroque 1989). The vegetation of Montagne d'Ambre is rainforest, with moist montane rainforest above and lowland rainforest below 800 m elevation (vegetation types of White 1983). The forest below 800 m appears to be transitional in form to the surrounding much drier deciduous forests that are at 0–300 m in elevation. The first National Park in Madagascar was created at Montagne d'Ambre in 1938, with a surface area of 18,300 ha. The Forêt d'Ambre Special Reserve (4810 ha) was created at the same time. These two protected areas include forest between 417 and 1474 m in elevation.

Two camps were used during this study, with the survey plots established in close proximity. The first camp, Antaniboka River, was centered at 12°32.22'S, 49°10.65'E, 1150 m elevation in montane forest, and was occupied from 15 November 1991 to 15 December 1991. The second camp, Antaniboka River Fitalana, centered at 12°29.33'S, 49°10.28'E, 650 m elevation in lowland rainforest, was occupied from 21 December 1991 to 20 January 1992. This period represents the start of the rainy season for Montagne d'Ambre.



Fig. 1. Map of northern Madagascar showing Montagne d'Ambre.

Methods

The horizontal plots measured 30 x 100 m and were located in valley bottom/slope primary rainforest undisturbed by previous collecting or surveying. Plots were chosen without prior knowledge of the reptile species present. Each plot was divided into 10 x 10-m cells. Brightly colored flagging on tree branches was used to mark the plot boundaries and the center of each cell. Searches for reptiles were made at night between 2000–0100 h using headlamps. Between nine and 13 workers searched the entire plot by slowly walking and scanning for a period of two to three hours. The forest floor and understory vegetation up to six meters high was searched. Chameleons and diurnal geckos were found in their night time roosting positions (Purcher 1974; Raxworthy 1991). Nocturnal geckos (*Gekolepis*, *Uroplatus*, *Pseudoeurycea*) and snakes were sampled by scanning tree-trunks, exposed foliage, and the forest floor. Geckos and chameleons were captured and uniquely marked with white correction fluid. A spot code was used to give a unique number to each capture, by ventrally marking the limbs, tail, and body with one or two spots. The marked geckos and chameleons were released at the point of capture. The sex and closest plot cell coordinate were recorded for each capture and recapture. Two or three searches were made on each plot, with time intervals of two to seven days between searches.

Results

The coordinates, search dates, and number of searches for each of the three plots were: Plot 1 centered at 12°32'30"S, 49°10'23"E, 7 December 1991 and 11 December 1991, 9–10 searches; Plot 2 centered at 12°29'23"S, 49°10'47"E, 29 December 1991, 3 January 1992 and 10 January 1992, 13–15 searches; Plot 3 centered at 12°29'48"S, 49°10'30"E, 13 January 1992, 16 January 1992, 18 January 1992, 11–13 searches.

A total of 376 individual reptiles were found on the plots representing eight gecko, eight chameleon, and three snake species. Some of the most frequently encountered species of gecko and chameleon are shown in Fig. 2. Nightly capture success and mean capture success per plot is given for each species in Table 1. A total of 486 captures (including 110 recaptures) were made on the plots, with a mean nightly plot success of 60.8 (range 47–79).

Recaptures were too few for most species to estimate population sizes by mark-recapture techniques. To increase the number of recaptures on Plot 2 and 3, we pooled the data from the second and third search (Seber 1982). Because all individuals were given unique marks, animals sampled twice during the second and third searches could be identified. The mark-recapture results for the chameleons *Calyptomantis boettgeri* (Plot 1) and *Brookesia stangei* (Plot 2 and 3) are summarized in Table 2. These two species accounted for more than half (57) of the entire survey recaptures (110). Symbols are as used by Seber (1982) and the population estimate is Chapman's (1951) modified Petersen estimate that gives less bias for small samples.

A 2 x 2 contingency table Chi Square test of equal catchability (Blower *et al.* 1981) at first recapture and second recapture was performed on the data for Plots 2 and 3. At first recapture individuals were handled and marked, but at second recapture animals were handled or inspected only. For *Brookesia stangei* Plot 2, $X^2 = 0.484$, 1 df, $P > 0.25$, NS; and Plot 3, $X^2 = 0.002$, 1 df, $P > 0.95$, NS. The process of marking did not significantly effect the probability of recapture compared to animals that were just handled.

Table 1. Reptile captures for each plot search.

Species	Specimen capture numbers							
	Plot 1		Plot 2			Plot 3		
Dates	7.12	13.12	29.12	3.1	10.1	13.1	16.1	18.1
Gekkonidae								
<i>Geholops maculata</i>	-	-	1	0	0	0	0	1
<i>Lygodactylus madagascariensis</i>	-	-	2	2	2	3	3	4
<i>Phelsuma lineata</i>	-	-	-	-	-	0	0	1
<i>Paroedura ericeps</i>	-	-	3	10	3	3	0	1
<i>Paroedura nasirgoffi</i>	-	-	-	-	-	3	4	4
<i>Uroplatus ebenaui</i>	9	7	3	5	1	1	2	3
<i>Uroplatus fimbriatus</i>	-	-	1	0	0	0	1	1
<i>Uroplatus saurus</i>	-	-	0	1	1	3	7	4
Chamaeleonidae								
<i>Brookesia ebenaui</i>	-	-	1	0	0	-	-	-
<i>Brookesia nasirgoffi</i>	-	-	25	23	23	45	50	54
<i>Brookesia umbellata</i>	-	-	10	9	11	-	-	-
<i>Brookesia subulanaui</i>	-	-	7	7	5	-	-	-
<i>Calumma boettgeri</i>	35	40	0	0	1	-	-	-
<i>Calumma boissacoti</i>	5	4	-	-	-	-	-	-
<i>Calumma calopharynx</i>	3	4	-	-	-	-	-	-
<i>Avicula picta</i>	-	-	2	1	0	3	3	3
Colubridae								
<i>Acanthina trita</i>	-	-	1	0	0	0	0	2
<i>Geocalcar bifasciatum</i>	-	-	1	0	0	-	-	-
<i>Lycaeus amabilis</i>	-	-	-	-	-	0	0	1
Total captures	51	55	57	62	47	41	73	79

For *Calumma boettgeri* and *Brookesia nasirgoffi*, there were sufficient recaptures to measure the degree of individual movement between the first and last plot searches. Approximate individual movement was calculated as the straight-line distance between the centres of the cells in which the individual was captured. *Calumma boettgeri*, a highly arboreal species (found roosting and active at two to at least six metres height), moved 10–70 m ($n=13$, median=30 m) over a period of four days. *Brookesia nasirgoffi*, typically found on the forest floor (roosting 0.3–2.0 m above ground), moved 0–40 m ($n=15$, median=10 m) over a period of five days and 0–77 m ($n=10$, median=10 m) over a period of 12 days.

Discussion

The number of recaptures was too low for most species to calculate population estimates by mark-recapture methods. In the cases of *Paroedura*, *Geholops*, and *Uroplatus*, this may be due to the difficulty in sampling these highly arboreal geckos, with most of the population always too high in the canopy to observe. The low numbers of the two diurnal geckos *Phelsuma lineata* and *Lygodactylus madagascariensis* probably underestimate their true densities (based on numbers of active individuals seen during the day). The roosting

habitats of these diurnal geckos, clinging to the tops or undersides of leaf blades at two to at least four meters above the ground, make them difficult to sample. The single *Brookesia ebenus* found on Plot 2 suggests that this species occurs at much lower densities than the other three *Brookesia* species. *Brookesia ebenus* had a smaller low capture rate at Manongarivo, with just two found over 44 days compared to 102 *B. stangei* (Raxworthy 1991). Because the roosting behaviour of *Brookesia ebenus* appears similar to other *Brookesia*, it does not seem likely that this species was under-sampled. The typical chameleons, *Calumma* and *Pseudocorone*, were more difficult to find than the *Brookesia* dwarf chameleons because their roosting sites were typically much higher up in the canopy (two to at least six meters). We suspect a significant proportion of typical chameleon populations are roosting above six meters and thus were missed during the plot surveys.

Both *Calumma boettgeri* and *Brookesia stangei* will move up to 70 m horizontally over 4-12 days, although the median distance moved during the plot surveys was 30 m for *C. boettgeri* and 10 m for *B. stangei*. It is clear that both these small species are capable of moving significant distances over a short period of time, suggesting that individuals are not necessarily fixed to a small territory. For larger African species (*Chamaeleo jacksoni*, *C. horneboldi*, *C. lateralis*, and *C. dilepis*) Tonopaeu *et al.* (1988) reported average daily movements of 1-12 m. However these authors found a significant decrease in daily movement for chameleons found together in pairs, with average movement in all four species being less than one metre. None of the Montagne d'Ambre animals were found roosting in pairs, although we have occasionally observed this behaviour at other sites in Madagascar.

The mark-recapture population estimates for the plots are probably overestimates, based on the significant movements we recorded in this study, and the open nature of the plots. In particular, immigration of unmarked animals into the plot would have had the effect of reducing the proportion of marked animals captured. Another source of error may be due to loss of marks as a result of skin sloughing, during the sampling period (4-12 days). To reduce both these sources of errors, we suggest future studies reduce time between sampling to a minimum—ideally successive nights, for roosting species sampled at night.

The differences in species composition found between Plot 1 (1130 m elevation) and Plots 2-3 (650 m elevation) are largely due to the elevational distribution limits found at Montagne d'Ambre (Raxworthy & Nussbaum 1994). The majority (61%) of amphibians, reptiles, and small mammals at Montagne d'Ambre have distributions restricted to forest either above or below 900 m elevation, reflecting the transition between lowland and montane rainforest in Madagascar. Only two species, *Uroplatus ebenus* and *Calumma boettgeri*, were found on both the montane and lowland rainforest plots, and in both cases their densities were much higher in montane forest (especially so for *Calumma boettgeri*).

The most unexpected result was the very different species composition of *Brookesia* and *Pseudocorone* found between Plot 2 and Plot 3. These plots were separated by the Antomboka River, which is 1-5 m wide at this point, with Plot 2 east and Plot 3 west of the river. The plots were at the same elevation and within 300 m of each other. *Pseudocorone stangei* was found only on Plot 3 and *Brookesia ambreana* and *Brookesia antakarana* only on Plot 2. All three species were common on the plot where they occurred. These plot distributions were completely consistent with distribution information obtained from other observations and collections made locally on both sides of the river.

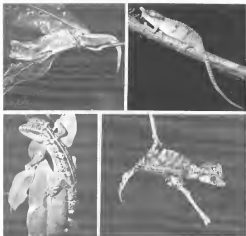


Fig. 2. *Brookesia stumpffii* (top left), *Calumma boettgeri* (top right), *Paroedura stumpffii* (lower left), *Uroplatus ebenaui* (lower right).

Table 2. Chameleón mark-recapture data: $n1$ = number of individuals marked in first search, $n2$ = number of individuals caught in subsequent search, $m2$ = number of marked individuals in subsequent search, N^* = Chapman's (1951) modified Petersen estimate of population size, V^* = approximate variance.

Species	Plot	$n1$	$n2$	$m2$	N^*	$11.96 \times V^*$ approx. 95% confidence limits	V^*
<i>Calumma boettgeri</i>	1	35	40	13	104.4	± 33.9	298.2
<i>Brookesia stumpffii</i>	2	35	42	18	57.8	± 10.0	28.0
<i>Brookesia stumpffii</i>	3	43	78	26	133.6	± 26.0	135.0

We suspect that the Antomboka River, even though modest in size, is an effective local barrier to dispersal for these dwarf chameleons and geckos. Along this stretch of the river the understory canopy is completely broken, and the overstory canopy largely broken. We never saw *Paroedura* or *Brookesia* above four meters in height, and species of these genera probably do not climb into the overstory canopy. Because these groups appear to be restricted to forest understory, rivers that cause a break in the understory canopy may be effective barriers to local dispersal.

Where *Paroedura oviceps* is sympatric with *P. stangei* (Plot 3), the number of *P. oviceps* sampled is much lower than where it is found alone (Plot 2). Similarly, where *Brookesia stangei* is sympatric with *Brookesia andravensis* and *Brookesia arakana* (Plot 2), the number of *B. stangei* observed is much lower than where it occurs singly (Plot 3). These preliminary observations suggest the possibility of competition between these species in microsympatry.

Conclusions

Detailed nocturnal searches of the 100 x 50 m plots rainforest plots, with teams of nine or more people, can yield consistently more than 45 reptile captures a night at Montagne d'Andoh. During the rainy season. This type of sampling therefore offers potential for the long term monitoring of populations, provided that sampling team effort can be standardized (for example using the same team members). However, the numbers of recaptures that we recorded in this study, and the substantial movement observed for the most commonly recaptured chameleons, do not suggest that mark-recapture studies can be used to effectively estimate population size for the plots. The variation in species sampled across the three plots further highlights the importance of elevation, and the potential influence of local landscape features (in this case, possibly a small river disrupting dispersal), on reptile community structure at Montagne d'Andoh.

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Survey of the non marine molluscs of Mayotte

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Abstract: A survey of the non-marine molluscs of Mayotte island recorded 69 species, including 47 endemics (68%). The Strophodontes make up 43% of species. This may be the highest percentage of endemism of snail species anywhere in the world.

Key words: Comoros, conservation status, diversity, Mollusca.

The land snails of the Comoro Islands are relatively well known with over 118 described native species. Most of what is known about the islands' snail fauna is based on collections from the nineteenth century. This has been reviewed by Fischer-Piette and Yukafinovic in 1974.

For 2 weeks in April 2001 Dr P Bouchet and Mr A. Abdou of the Malacology department of the National Museum of Natural History Paris (MNHN), carried out a survey of non marine molluscs on the island of Mayotte in the Comoros. They were joined by the author for 1 week. This was the first systematic non marine survey conducted on Mayotte. The results of the survey are detailed below.

Introduction

The Comoros Islands lie at the northern entrance to the Mozambique Channel. They consist of an archipelago of 4 islands. The largest is Grande Comore, 1025 square km, followed by Anjouan, 424 square km, Mayotte 374 square km and the smallest Moheli, 211 square km. The volcanoes which formed the Comoros began to emerge from the sea about 15 million years ago. Mayotte was the first to emerge, followed by Anjouan, Moheli and finally Grande Comore which still has an active volcano and the highest mountain in the Comoros – 2361 metre Mt Karthala (Swaney & Wilcox 1994).

Mayotte is the most easterly of the Comore Islands and is the only one still belonging to France. It's political status is that of 'Collectivité territoriale'. The territory of Mayotte consists of 2 main islands: Grand Terre (356 km square) and the island of Dézaoudzi or Petite Terre (18 km²) which once housed the main administrative center. Mayotte, as the oldest of the Comore Islands, has mostly low rounded hills and a maximum altitude of 660m. It has a variety of micro climates ranging from arid to humid. The population was in 1999 1 30,000 and is growing rapidly.

As a result of extensive shifting agriculture only 1,150 ha of the native forest cover remains. This is nearly all humid forest confined to mountain tops with some small areas of dry lowland forest. Much of the rest of the island is covered in secondary vegetation. This regeneration has been possible because of the decline of shifting agriculture associated with increased living standards, linked to the political status of the territory (Lorette 1999).

Methods

The survey of Mayotte was focused on the remaining areas of native vegetation. Using information from Louette (1999) and from discussions with the Mayotte forestry service, the remnant areas of native forest were identified and most were visited. In addition areas of geological interest such as the base of cliffs and the lake of Dziani Dzaha on Dzauzou, were also visited. Sampling was also done in areas of secondary forest. The freshwater fauna and that occurring in saltmarshes and mangroves (Elabrids etc), was only incidentally surveyed.

Table 1 Mayotte Molinera collected during the survey

Local		Local		
1	<i>Tropidophora usambarana</i>	34	<i>Ecdontobius croceus</i>	
2	<i>Tropidophora capensis</i>	35	<i>Ecdontobius modestus</i>	
3	<i>Tropidophora usambarana</i>	36	<i>Paradidius auratus</i>	
4	<i>Tropidophora usambarana</i>	37	<i>Paradidius incognitus</i>	
5	<i>Tropidophora usambarana</i>	38	<i>Paradidius lineatus</i>	
6	<i>Cyclodorus microscopus</i>	39	<i>Paradidius minor</i>	
7	<i>Cyclodorus sp. n.</i>	40	<i>Paradidius usambaranus</i> (?)	
8	<i>Cyclodorus sp.</i>	41	<i>Sabulobius granulatus</i>	
9	<i>Cyclodorus sp.</i>	42	<i>Tigridobius</i>	
10	<i>Cyclodorus debilis</i>	43	<i>Exochus</i>	
11	<i>Cyclodorus griseus</i>	44	<i>Paradidius sp.</i>	
12	<i>Cyclodorus rufipes</i>	45	<i>Trachycyrtus arachne</i>	
13	<i>Cyclodorus minor</i>	46	<i>Trachis rufipes</i>	
14	<i>Aschei usambarana</i>	47	<i>Aschei usambarana</i>	
15	<i>Aschei debilis</i>	48	<i>Trachis lineatipes</i>	
16	<i>Quadrus sp. nov.</i>	49	<i>Acrostichus sp.</i>	
17	<i>Gasterobius minor</i>	50	<i>Exochus usambaranus</i> (?)	
18	<i>Stenobius aculeatus</i>	51	<i>Nannus concoloratus</i>	
19	<i>Gasterobius cygnellus</i>	52	<i>Nannus usambaranus</i>	
20	<i>Gasterobius usambaranus</i>	53	<i>Exochus sp.</i>	
21	<i>Gasterobius debilis</i>	54	<i>Exochus dipentis</i>	
22	<i>Gasterobius usambaranus</i>	55	<i>Microgasterus usambaranus</i> (?)	
23	<i>Gasterobius usambaranus</i>	56	<i>Kalobius concoloratus</i>	
24	<i>Gasterobius debilis</i>	57	<i>Nannus concoloratus</i>	
25	<i>Gasterobius debilis</i>	58	<i>Nannus usambaranus</i> (?)	
26	<i>Gasterobius debilis</i>	59	<i>Gasterobius usambaranus</i>	
27	<i>Gasterobius usambaranus</i>	60	<i>Papilio</i> (?) sp. nov.	
28	<i>Gasterobius debilis</i>			
29	<i>Gasterobius debilis</i>	Introduced	11	<i>Archamia fulva</i>
30	<i>Gasterobius debilis</i>		12	<i>Archamia usambarana</i>
31	<i>Gasterobius debilis</i>		13	<i>Sabulobius usambaranus</i>
32	<i>Gasterobius debilis</i>		14	<i>Allogasterus griseus</i>
33	<i>Gasterobius sp. nov.</i>		15	<i>Allogasterus chrysanthus</i>
Mangroves M1	<i>Acrostichus punctatus</i>	Freshwater	F1	<i>Microgasterus usambaranus</i>
M2	<i>Acrostichus punctatus</i>		F2	<i>Exochus usambaranus</i>
M3	<i>Microgasterus (Trachis) usambaranus</i>		F3	<i>Septoria horreorum</i>
M4	<i>Microgasterus griseus</i>		F4	<i>Nannus sp.</i>
M5	<i>Cicadula fulva</i>		F5	<i>Exochus sp.</i>
M6	<i>Acrostichus punctatus</i>		F6	<i>Exochus sp.</i>
M7	<i>Microgasterus sp.</i>			

Table 2 Summary of described native snail and slug species (from Procher-Petit & Vekemans 1994)

	Grand Comore	Moheli	Anjouan	Mayotte
Endemic species	18	2	13	47
Shared with other island in Comoros	12	0	23	17
Shared with Madagascar	-	5	-	5
Shared with Zanzibar	-	1	-	-
Total	30	12	41	69

Table 3 Total number of species of described snails and slugs in the Comoros Islands

	Number	% of native species
Endemic to Grande Comore	18	15
Endemic to Moheli	2	2
Endemic to Anjouan	13	11
Endemic to Mayotte	47	40
Shared with 2 or more islands	27	23
Shared with Madagascar	10	8
Shared with Zanzibar	1	1
Total native species in the Comoros Island	118	

Results

The preliminary results of the survey are set out in table 1. They are preliminary as they are based on field notes and sorted material (including leaf litter samples) from the 10 stations surveyed with the author (out of a total of 18 stations surveyed). While slugs were collected at all stations, these have not yet been examined. Although only preliminary, the data from these 10 stations are sufficient to provide good information on the current diversity and conservation status of the Mayotte land snails.

Discussion

The land snail fauna of Mayotte has a number of features that the survey served to confirm. Tables 2 and 3 give a break down on the native land snail fauna island by island. From this it can be seen that Mayotte has the greatest number of species as well as the greatest percentage of endemics: 68%. While this can perhaps be partially a collection artifact (Mayotte has always been the most French and hence the better collected of the islands), it reflects logically the greater age of the island. Mayotte has a few endemic genera including (*Pseudoloma*) of the carnivorous snail family Streptaxidae. It also has the greatest radiation of the Subulinidae in the archipelago.

The overall snail diversity of the Comoros (118 described native species) compares closely to that of the Mascarenes with at least 146 native species (Griffiths 1996). There are however a number of differences. The Comoros have a higher diversity at a family level, reflecting their less isolated position. Also the Mascarenes lack completely the impressive radiation of slugs found in the Comoros. One area the Comoros in general and Mayotte in particular, have in common with the Mascarenes is the extensive radiation of carnivorous snails. In Mauritius streptaxid species represent 26% of the snail fauna, which is already considerable. In Mayotte they represent an exceptional 43% of the fauna. This is probably the highest percentage of carnivorous snail species anywhere in the world. Mayotte (and Anjouan) is also home to the largest streptaxid snail in the world, *Euhadra ovalis* which can measure up to 51mm (shell length).

Mayotte is also home to one of the most bizarre of all snails, the tiny uncoiled

Cyclophorus mariei Morelet, 1881. This snail can be found adhering to mossy rocks and logs (Classified file) in all areas of native forest.

From a conservation status stand point the results were very surprising in a positive way. Given that the main knowledge of the Mayotte fauna is based on the collections of Mr M. Marie in the late 19th century and that since then most of the native forest has gone, it was expected to find a conservation situation analogous to Mauritius. There 32 % of the species overall and 39% of the endemics are extinct and much of the remainder critically endangered (Griffiths 1996). In Mayotte, as soon as you went into any area of native forest, it was quickly apparent that native snails were everywhere. Many endemics, including *Cyclophorus mariei* are very common. Significantly all the large species are present. The three largest endemics *Tropidophora newberryi*, *Tropidophora nanthocheilana* and *Edentoloma ovalis* and many of the smaller snails and slugs also occur commonly in secondary forest and even in gardens. Furthermore one species recorded from dead collected specimens and believed at that time to be extinct: *Tropidophora zamburana* (Morelet, 1881), was turned up alive in the survey. The survey also turned up at least two and possibly more new species. While a few Mayotte endemic species were not found it is likely that they may still be present.

Although a number of introduced species occur on Mayotte, no trace was seen of *Engelmannia rosea* and *Gomarcis quadrilobatus*. Both these species have been introduced to Grande Comore and it was feared that they may have been introduced to Mayotte. The devastating impact of one of these species (*E.rosea*) on native snail faunas is well known (Griffiths *et al* 1993). Interestingly *E.rosea* has now been introduced to Reunion where it may turn out to be a threat to Reunion's native snails (pers. observation of the author).

The survey showed that from a conservation stand point the native snails of Mayotte are in a relatively good situation. Although only limited areas of native forest remain, they contain healthy populations of most of the land snail fauna. It is also clear that human pressure on Mayotte's forest have declined over the last 20 years. It is essential however that remaining areas of native forest are protected fully. The conservation situation on the other islands of the Comoros is however very alarming. A high priority should be accorded to surveying these islands soon.

Acknowledgements

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A note on synchronous flowering of Hypoxidia rhizophylla (Baker)

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Of the three species of plants in the family of Hypoxidaceae found in Seychelles, *Hypoxidia rhizophylla* is the most widespread on Silhouette island. The plants are found at all altitudes and grow closely together in large patches. They differ from *H. moheensis* in having the ability to root from the leaf tips. Flowers are produced at the base of the plant and the putrid scent is characteristic of fly-pollinated flowers (Wise 1998).

On 12th August 2001, a synchronous flowering of *H. rhizophylla* was seen on the Jardin Maroon trail on Silhouette. During the ascent of the trail at 14.00hrs. no flowers were seen. On the descent of the trail at 17.00hrs. flowers were counted on 34 plants. Colour varied from pale yellow to deep magenta with the majority being close to orange. Flowering occurred during a period of low rainfall (32mm over 12 days), following a period of 23 days in which only 6mm were recorded.

On 6th May 2002 on the same trail two flowering plants were found at 9.00hrs., one with a single very deep maroon flower, the other with two stems with two deep ochre flowers on each stem. On the way down, there were many flowers in the population found flowering in August 2001. Most of these had two flowers, and all deep maroon. The only exception was a plant higher up the path, which was deep ochre, with 4 flowers. This is in contrast to the earlier observation when flowers were pale yellow or orange and single. These observations were made 8 days after the last significant rain (9mm).

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Wise, R. 1998. *A Fragile Eden*. Princeton University Press.



Fig. 1. *Hypoxidia rhizophylla* solitary flower, 12th August 2001

Attempted stick-insect predation by a wasp

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On Tuesday 12th March 2002 a wasp was observed attacking a stick insect at Jardin Maillon on Silhouette Island, Seychelles. The observation was made at 13:45hrs within 3 metres of the stream at the top of Jardin Maillon, on the vertical side of a dead fallen tree approximately 12cm diameter at the trunk base and 75cm above the ground.

A stick insect *Carausius seychellensis* (Bolivar, 1893) was observed being attacked by a single yellow wasp *Polistes olivaceus* (De Geer, 1773). The wasp flew toward the head and placed its body in a curved attacking position. The wasp had to adjust and re-adjust as the stick insect moved sideways and also reversed approximately 10cm down the trunk as the wasp was flying around. The wasp did not get a firm grip on the stick insect and flew off to the top of a stick 0.5m distant. The wasp cleaned its head and antennae, returned to the stick insect and attacked again. This time the attack was noticeably less aggressive and lasted approximately 15 seconds as opposed to the initial attack of 30 seconds. The wasp flew off again, stayed flying around in the immediate vicinity 3-5m distant, returned, landed on the same stick but approximately 30cm away. Meanwhile the stick insect had continued reversing and had covered another 5cm. The wasp did not attack a third time, cleaned itself again and flew off. It did not return for at least the next five minutes.

NOTES

Corals of Silhouette Island, Seychelles

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In 2000 the dredging of a harbour at La Passe, Silhouette Island, broke up a section of the fringing reef. In December 2001 a collection of corals found on the beach at La Passe was made. 14 families and 37 species were collected and identified from 'Corals of the World' (Veron & Stafford-Smith 2000). This included species from a range of depths.

Gorgonias

Corallium cf. nobile

Fabrya muricea Linnaeus, 1758

Ostrocorallia

Acroporidae

Acropora hesperichthys (Ehrenberg, 1834)

Acropora dharciana (Dana, 1846)

Acropora formosa (Dana, 1846)

Acropora rubra (Dana, 1846)

Montipora digitata (Dana, 1846)

Agaricidae

- Coelomeria angari* Vaughan, 1918
- Gardineriaria planulata* (Dana, 1846)
- Leptomeria papyracea* (Dana, 1846)

Caryophyllidae

- Heterocystus aspicularis* Milne Edwards & Haine, 1848

Euphyllidae

- Euphyllia glabrescens* (Chamisso & Eysenhardt, 1821)

Favidae

- C. phaeus microphallus* (Lamarck, 1816)
- Favia fava* (Forsk  ll, 1775)
- Favia lara* (Klunzinger, 1879)
- Favia pallida* (Dana, 1846)
- Favia speciosa* Wells, 1954
- Favia stelligera* (Dana, 1846)
- Goniastrea murata* Veron, 2000
- Leptopora phrygia* (Ellis & Solander, 1786)

Fungidae

- Cyclonema parviformis* (Boschma, 1923)
- Fungia palmata* Veron & Vautier
- Fungia repanda* Dana, 1846

Heloporidae

- Helopora coerulea* (Pallas, 1766)

Massidae

- Synphyllia recta* (Dana, 1846)

Oculinidae

- Galaxea fasciculata* (Linnaeus, 1767)

Pocilloidae

- Echinophyllia arkhara* (Saville-Kent, 1871)

Pocilloporidae

- Pocillopora damicornis* (Linnaeus, 1758)
- Pocillopora eydouxi* Milne Edwards & Haine, 1869
- Pocillopora verrucosa* (Ellis & Solander, 1786)
- Seriatopora hyacinthina* Dana, 1846
- Seriatopora guttata* Veron, 2000

Poridae

- Porites nigrescens* Dana, 1846
- Porites profundus* Rehb  rg, 1892
- Porites rui* (Forsk  ll, 1775)

Scleractinidae

- Pseudococcarda confusa* (Esper, 1797)
- Pseudocentrotrea sapax* Yabe & Sugajima, 1935

Of the species identified the Caryophyllidae are of particular interest. Two specimens of

Hamaxothia aspericarinata were collected. This zoosymbiotic Indo-Pacific species has previously been recorded from Arida although the Indian Ocean records are omitted from Veron & Stafford-Smith (2000) and there is some confusion over the identity of the Indian Ocean species. In Seychelles two other species have been recorded: *H. alternata* Verill, 1865 (Poivre) and *H. ankaria* (Verill, 1866) (Arida, Poivre and D'Amos). In addition *H. hawaiiensis* Gray, 1849 is recorded from the Indian Ocean. As with other members of the genus, *H. aspericarinata* is associated with the commensal sipunculan worm *Apidousiphon corallivorus* Skilleen.

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NOTES

Osteological finds on Trois Mamelles mountain extends the known ecological range of the extinct endemic Mauritian tortoise *Cylindraspis* sp.

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This note reports the find of *Cylindraspis* bones made by the author on the south facing flank of the Trois Mamelles mountain in 1996 at latitude 20° 18' 31" S and longitude 57° 26' 43" E. A large number of small fragments of carapace and possibly of plastron, a humerus and a femur were uncovered in deposits under a rock overhang on a ledge at an altitude of 480m together with a rich collection of snail shells. Many of these shells belong to long extinct species, testifying to the old age of the deposit. Similar deposits have indeed been dated at 2,500 to 1,000 years (Griffiths 2000). Samples of the bones were sent to the Natural History Museum, London for identification which was unfortunately not possible beyond genus level (pers. comm. N. Arnold).

Mauritius had two endemic species of land tortoise of the genus *Cylindraspis* (Austin & Arnold 2001). These were *C. trivittata* and *C. nupta* both described by Günther in 1873 who originally placed them in the genus *Tortudo*. Both went extinct in the 18th century as a result of the combined action of hunting by humans and predation by introduced vertebrates (Cheke 1987). Historical records mentioned the abundance of tortoises in coastal areas and on several islets around Mauritius. There were however no records of endemic tortoises living far inland away from the coastal lowlands although a closely related species was known to have done so on nearby Réunion Island (Cheke 1987).

As reported in the literature, *C. hildebrandi* bones were subsequently uncovered at 17 sites over Mauritius, 11 of which are in the lowlands below 50m above sea level (Fig. 1).

These include bones from limestone caves on Ile aux Arguettes off the SE coast of Mauritius and La Pointe (SW coast) and from sand dunes in Flac en Flac on the west coast (Austin & Arnold 2001) as well as from the Mare aux Songes swamp in the southeast (Arnold 1979) and a variety of other marshes (Bour 1984). The remaining 6 finds were probably all made between 150–280m a.s.l. Three of these sites are described well enough to have precise altitudes. They are ‘Mt Zacc’, 1.4km west of Belle For Mountain (ca. 150m) (Austin & Arnold 2001), Camp de Mosque (235m) and Palmie (280m) (Bour 1984). The other three finds were collections made by Louis Etienne Thirion in the 19th century and unfortunately the site descriptions are too vague to allow precise location. Thirion collected the bones from what appear to have been a number of sites in caves and scree at Arne Courtois, La Pouce and Corps de Garde (Bour 1984). While possible, it is unlikely that these collections could have been made above 450m in altitude, given that surveys have as yet failed to reveal any caves in those areas above such altitude. On the other hand, subfossil deposits 1,000–2,500 years old are known from under rock overhangs (‘caves’ of Thirion?) in the lower reaches of La Pouce towards Port Louis, 1.5km from the summit (Griffiths 2000) and bone bones had already been collected at the foot of the Corps de Garde mountain before Thirion. Indeed, it is even possible that Thirion’s sites might have been as low as 100m in altitude in the Pouce Valley and Arne Courtois and 200m at Corps de Garde. For these three sites, the midpoints between the possible extremes were used in Fig. 1.

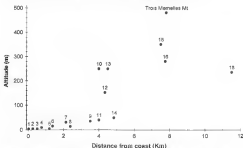


Fig. 1. Localities of finds of *Cyrtodactylus* bones on Mauritius, indicating altitude and distance from the coast: 1. Ile aux Arguettes limestone cave; 2. La Pointe; 3. Flac en Flac sand dunes; 4. Mare aux Songes; 5. Mare du Port; 6. Les Quatre Cocos; 7. La Mare La Chaux; 8. Mare Sèche; 9. Vallée des Palmes; 10. Arne Courtois; 11. Flacq; 12. ‘Mt Zacc’; 13. La Pouce; 14. Rache Marie; 15. Corps de Garde; 16. Palmie; 17. Camp de Mosque. The site recorded in this note is marked as Trois Mamelles Mt. The culminating point on Mauritius is 828m and the greatest distance from the coast is 17 km.

The find reported here thus represents the highest confirmed altitude (480m) at which *Cylindrocybus* bones have until now been uncovered in Mauritius. The site is also 7.9 km from the nearest coastline which makes it the second most inland locality for *Cylindrocybus* on the island after Camp de Marqne (11.5 km from the nearest coast).

This find provides evidence that the Mauritian tortoises did not keep to the coastal areas or low lands but instead also ventured far inland till fairly high altitudes. They could thus have been an important biotic factor impacting on the inland vegetation communities via seed dispersal and herbivory.

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NOTES

First results of radio-tracking black mud turtles *Pelusios subniger parietalis*

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The Seychelles subspecies of the African black mud turtle *Pelusios subniger parietalis* is endemic to the Seychelles islands where it is found on 5 islands: Mahé, Cerf, Praslin, La Digue and Fregate. Both this subspecies and the Seychelles yellow-bellied mud turtle *P. castaneoides usurgulensis* are Critically Endangered due to habitat loss, predation and invasion by alien water plants (Gerlach & Canning 2001). Declines continue with the recent loss of small populations on Cousin island and possibly also Curieuse, these are probably stochastic losses and highlight the vulnerability of fragmented populations.

The Seychelles Terrestrial Conservation Project of The Nature Protection Trust of Seychelles aims to provide these species with a secure future. The project recorded the first successful captive breeding in 2000 for *P. subniger*, since then 23 hatchlings have been reared and eggs of *P. castaneoides* have been obtained.

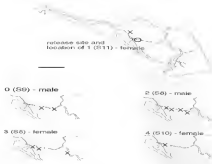


Fig. 1. Terrapin movements at Grande Barbe 13th March - 11th May 2002, scale bar 250m.

In March 2001 the first experimental release of *Pelusios subreptus parietalis* was carried out on Silhouette island. This island used to support mud turtles until the 1930s when they were eaten by the resident human population. This threat is no longer significant and the island has the best potential to support large populations of these species. The experimental release of 5 adults was used to test release methods and to obtain data on habitat preferences and use through radio-tracking. The terrapins were released in the Grande Barbe marsh, the largest semi-natural marsh left in Seychelles. All 5 were fitted with radio-tags funded by the British Chelonia Group. The results of monitoring showed that all the terrapins had settled in specific areas within a few days, 1 about 30m from the release site in a fresh water stream, the other 4 around the release site, with overlapping ranges in part of the stream prone to occasional salt-water incursion. One buried itself on land for a day but otherwise all have stayed in the water, with no over-land dispersal. The pattern of movement over 2 months is shown in Fig. 1. In the first week of release three terrapins moved over 200m (terrapins 0, 1 and 2), the other two stayed within 20m of the release site. For most terrapins there was a decrease in movement after 2 weeks of release; terrapins 0, 1 and 4 appeared to have settled into areas of approximately 10m of river. In the last two months of monitoring reported here (April-May) terrapins 0, 1 and 4 remained in the same positions, terrapin 2 had moved only 20m but terrapin 3 (initially the most sedentary individual) moved 300m. These results suggest that

terrapins will move only a limited distance from the release site, although some apparently settled individuals will move some time after release, these differences do not correlate to size or sex. These results provide valuable data on movement and habitat selection and are highly encouraging for the potential to establish new populations through reintroduction.

Monitoring will continue as long as the tags last which should provide 6 months of data. The data collected have been used in the preparation of the 'Seychelles Terrapin Action Plan' (Gerlach 2002) and will influence future releases with the aim of establishing new, secure populations.

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NOTES

A new record of an alien pond weed (*Elodea canadensis*) in Seychelles

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In December 2001 Canadian pondweed *Elodea canadensis* Michaux (Hydrocharitaceae) was observed growing on Mahé island. It was present in the shallow, heavily polluted streams of the town of Victoria and in ornamental ponds. This species is an introduced member of an American genus which has become widely introduced and causes considerable ecological problems in water courses in Europe. Although there are no published records of this species from Seychelles it has apparently been present for a number of years (D. Dagley pers. comm. to R. Gerlach). So far it does not seem to have been widely dispersed unlike other imported water weeds such as water lettuce *Pistia stratiotes* Linnæus, if it does spread beyond Victoria it has the potential to cause major ecological problems in streams and marshes.